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EDSON AQUIFER TESTING PROGRAM
EDSON, ALBERTA

ARDA PROJECT NO. 28056, App. E

Prepared By

GRANT L. NIELSEN, P. GEOL.
HYDROGEOLOGIST

EDMONTON, ALBERTA
March, 1969

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Alberta Department of Agriculture
Water Resources Division
Soils, Geology and Groundwater Branch

EDSON AQUIFER TESTING PROGRAM
EDSON, ALBERTA

ARDA Project No. 28056, App. E

By

Grant L. Nielsen, P. Geol.
Hydrogeologist

Edmonton, Alberta
March, 1969

EDSON AQUIFER TESTING PROGRAM

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EDSON AQUIFER TESTING PROGRAM

Abstract

The Edson buried channel aquifer was drilled and pump-tested during the summer of 1968 in order to evaluate its full groundwater potential. The average safe pumping rate per well is 112 igpm, using a well spacing of 1500 feet along the centerline of the channel. Daily recharge to the aquifer is 19,880,000 gallons, of which only 1.3% is being used at present. The potential of this aquifer is considered adequate for all foreseeable domestic and industrial demands, except for a pulp and paper industry.

Two possible sites for artificial induction of river water were investigated. One, just west of the Hudson's Bay Oil and Gas Company plant has a safe yield of 96 igpm for a single well. The eastern site, just east of Yates, has no potential, as the aquifer is higher in elevation than the McLeod River.

A water supply suitable for Glenwood has been evaluated just south of the village itself.

Water quality was excellent in all the sites tested. No aquifer contamination has been detected, and chemical quality for all ions analysed is satisfactory for domestic use.

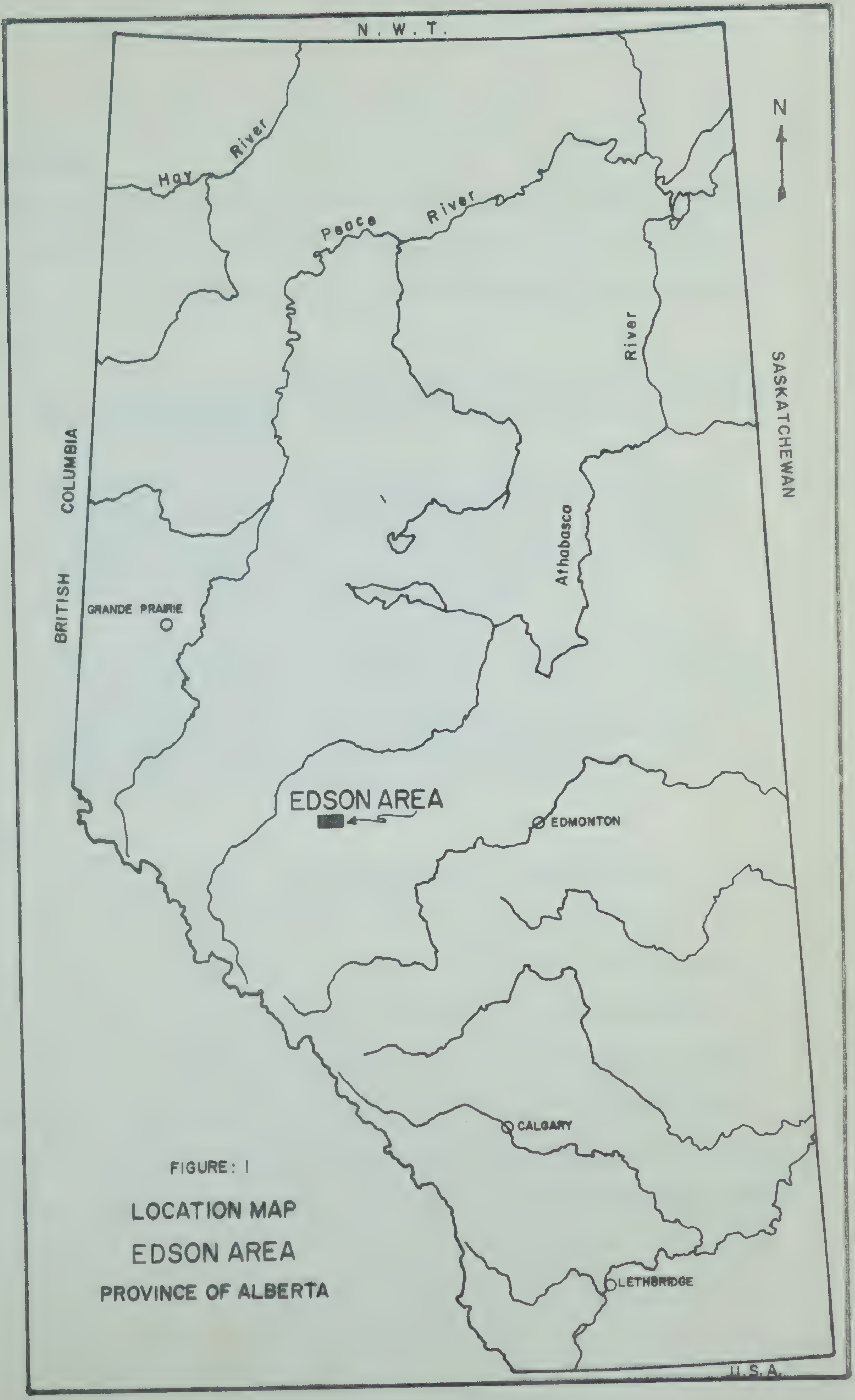


FIGURE: I

LOCATION MAP
EDSON AREA
PROVINCE OF ALBERTA

Purpose of Study

The Edson Aquifer Testing Program was undertaken to implement recommendations made by Stanley Associates Engineering (1967) in the Letter of Transmittal accompanying their report. There were three recommendations, as follows:

> 1. "That the Edson channel be investigated with a view to determine the ultimate potential of the aquifer and the capacity and spacing of wells in the aquifer.
> 2. That sufficient on-site investigation and aerial photographic interpretation be carried out on the two potential sites for induced infiltration to determine which site has the greater potential. This decision is necessary in order to determine in which direction, east or west of the Town of Edson, the Edson Channel Aquifer should be developed.
> 3. That the Town of Edson invite the Agricultural and Rural Development Administration to participate in the costs of carrying out the investigation of the Edson Channel Aquifer, and cursory investigation of the induced infiltration sites. Also that the Alberta Research Council, Groundwater Division be invited to assist in the calculations and interpretation of data to advise on the procedures for carrying out the field work."

Background

For many years, Edson obtained adequate water supplies from a field of wells bottomed in sandstones of the Tertiary Paskapoo Formation. By 1958, it became apparent that water levels in these wells were declining and that water demand was beginning to exceed supply. R.N. Farvolden, head of the Groundwater Division, Research Council of Alberta, was asked to investigate and make recommendations. He did so and postulated the presence of a pre-glacial channel in the broad valley adjacent to and south of the town. This valley was suggested to be an excellent potential source of groundwater.

In 1961 and 1963, Mr. Farvolden's successor, Don H. Lennox, assisted the town in drilling and testing the aquifer.

Further drilling was done in 1966, and a consulting firm was retained to evaluate the economics of municipal water development from the following sources:

Groundwater:

1. Paskapoo Sandstone Aquifers
2. Edson Channel Aquifer
3. Induced infiltration from McLeod River to Edson Channel

Surface Water:

4. McLeod River

The report concluded that the Edson Channel Aquifer should be used for municipal supply. Infiltration sites should be utilized to accomodate a large increase in population, or for industrial development.

Vanden Berg and Lennox (1968) calculated safe yields and proper well spacing for the channel, based upon pump test data interpreted by the Research Council of Alberta.

Gabert and Roed (1968) described the surficial geology of this region, with special emphasis on preglacial channels and their groundwater potential.

Work Done

The study was initiated with a helicopter survey along the McLeod River in March, 1968, to check the coincidence of pre-glacial and modern channels. The survey substantially verified the location of the pre-glacial channel as shown by Gabert and Roed. Portions of the modern river valley were later field-checked on foot.

Forty-one test-holes and wells were drilled along a ten-mile portion of the channel, from Yates in the east to the Hudson's Bay Gas Plant in the west.

Those drilled under contract have the suffix "P" after the well number, those drilled by a government-owned rig have "E" after the well number. Most of these holes were drilled in profiles normal to the trend of the channel. Since the presence of forests and swamps limited choice of drilling sites, most holes were drilled along the main roads. This work was done during the summer of 1968.

In this report, all available data is being used, whether obtained in this study or borrowed from previous work by other agencies. It is thus intended that the report be as complete a reference as possible for groundwater development in the area.

Most of the holes drilled in 1968 were in seven profiles (Figures 2 and 3, and 5 to 9), herein called:

Yates Profile
Lagoon Profile
Reservoir Profile
Cemetary Profile
Glenwood Profile
Answell Profile
Gas Plant Profile

A previously published profile, herein call "Golf Course Profile" is also included (Figure 4).

Geology

Bedrock of this area is composed of shales and sandstones of the Tertiary Paskapoo Formation. Over the thousands of years that this formation was subjected to uplift and erosion, a mature drainage system gradually developed upon it. Gabert and Roed (1968) describe a rather complex sequence of materials later deposited in this area upon the Paskapoo bedrock.

The lowest surficial beds stratigraphically are gravel layers, which lie directly on bedrock. They occur both in channels, and in terraces adjacent to these channels. Both were encountered in drilling at Edson.

These are deposits left by rivers which drained the area previous to Pleistocene glaciation.

A middle group of deposits includes till, glacial outwash and glacial lake sediments. A thick section of glacial outwash sand was encountered in drilling along the Ansell road. Locally, these sands may have considerable value as aquifers, but are not generally susceptible to such use. Glacial lake sediments tend to be calcareous clay and silt beds, and occur at the surface in much of the area. These were deposited in temporary lakes during glacial retreat, and are of no interest as aquifers.

An upper group of modern aeolian (windblown) sand, and alluvial silt, sand and gravel occurs in some areas. Alluvial materials are especially abundant along abandoned terraces and meander scars of the McLeod River. These could be developed for minor groundwater supplies in a few places.

For a more detailed description of these materials, the reader is referred to Gabert and Roed (1968) pp. 3-5.

Hydrogeology

The Edson aquifer varies from about ½ to 1½ miles in width and its maximum thickness is about 15 feet. The portion of the aquifer studied for this report is approximately 14 miles long, from Big Eddy (a whirlpool area of the McLeod River) in the west to the McLeod River in the east. Where the McLeod River cuts through the aquifer in these two areas, springs, seepages, and slumping occur. This indicates that, under natural conditions, groundwater is leaking from the channel into the river at both of these sites. The area of the channel useful for groundwater to Edson and vicinity is considered to be approximately 11.1 square miles. Its configuration is shown in Figure 11.

Although some of the channel actually consists of terrace gravel, rather than channel gravel, the differentiation was hydrologically insignificant. Figure 11 shows the configuration of the channel, including these terrace gravels.

Channel gravels have been modified somewhat by glacial action. Edson is on the borderline of Cordilleran and Laurentide glaciation. The Cordilleran glacier reached the Edson area first, as its source area was much closer. Its presence undoubtedly raised considerably the discharge and velocity of the stream which flowed in the Edson channel. This would explain some of the complexities of the channel, such as removal of some of the gravel, shown in Figures 5 and 8.

Non-pumping water levels for the channel average about 75 feet below surface, but in the Ansell Profile (Figure 8), this level is only 6 to 10 feet below surface. Here, the tremendously thick sequence of outwash sand readily transmits a large volume of groundwater laterally into the channel. Although outwash sand is present in much of the area (Gabert and Roed, Figure 3), it is separated from the buried channel in most places by a considerable thickness of till and is considerably thinner elsewhere.

Figure 12 is a profile along the thalweg, or deepest portion of the channel. It will be seen that it has a nearly uniform eastward- sloping gradient of about 12.5 feet per mile as compared with about 10 feet per mile in the modern McLeod River thalweg in the same area. The greater gradient in preglacial time explains the deposition of very coarse gravel in this channel during that period.

In three of the seven profiles, test-holes were completed as screened wells and pump-tested. These were in the Lagoon, Cemetary, and Gas Plant Profiles.

TABLE I

Transmissivity and Permeability of Wells, Edson Area

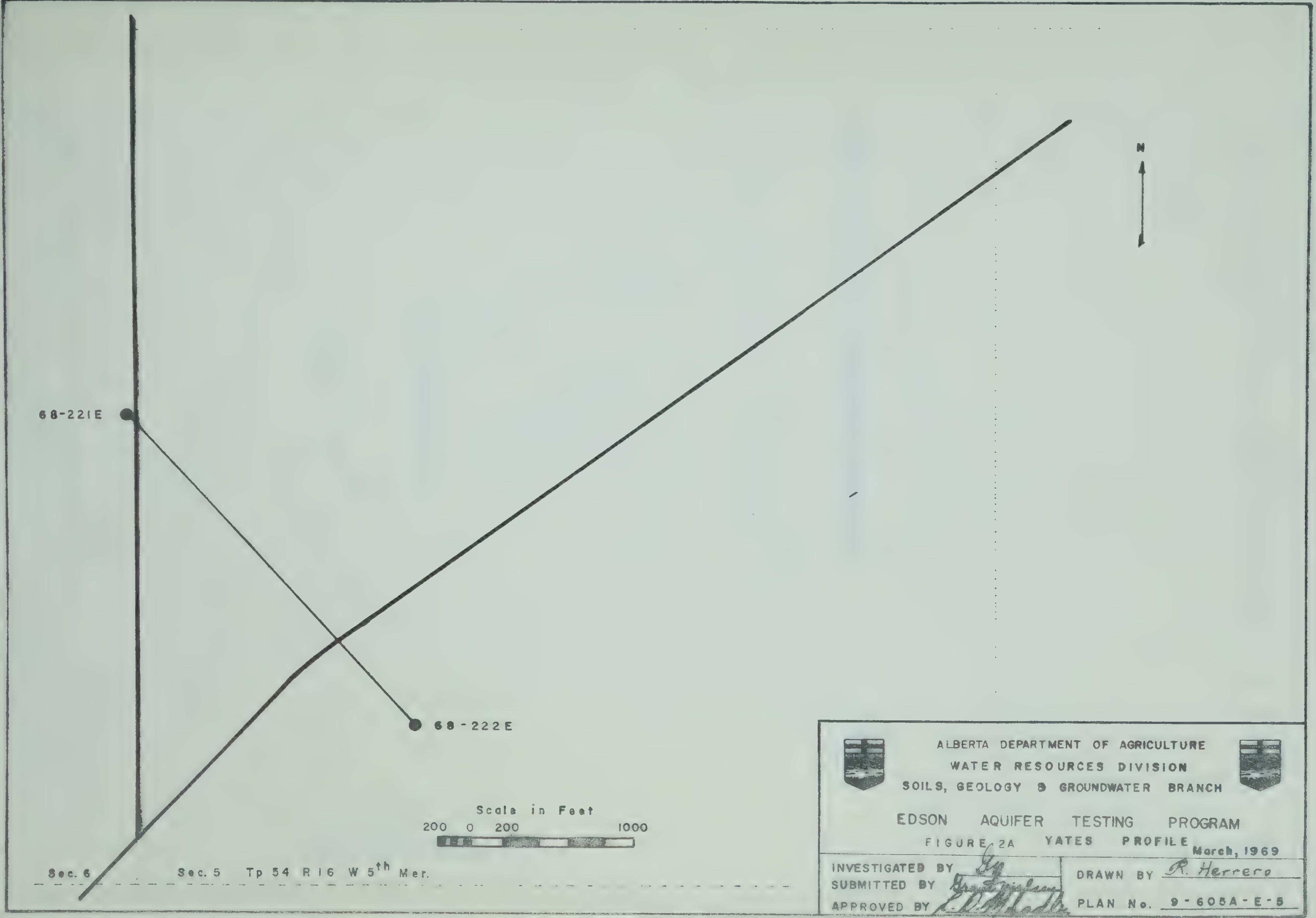
Well No.	Location	Gravel Thickness (m)	I	P = T/m
68-6P	5-24-53-17-W5	8	8,250	1,030
68-5P	8-23-53-17	10	9,100	910
68-4P	4-24-53-17	8	16,500	2,060
68-3P	1-23-53-17	7	12,550	1,790
68-13P	16-9-53-17	10	12,200	1,220
68-8P	7-16-53-17	6	19,800	3,230
68-12P	16-9-53-17	10	5,200	520
68-15P	2-17-53-17	6	*46,500	*7,750
68-14P	4-16-53-17	10	12,200	1,220
60-5	13-14-53-17	8	7,200	900
8	1-22-53-17	12	19,000	1,600
68-216E	15-2-53-18	14	8,300	1,310
	Average	10	12,750	1,435

* Doubtful value; not included in average

LEGEND

SOIL TEXTURE CHART

▩	VERY COARSE TEXTURED GRAVEL
░	COARSE TEXTURED CS. MS. FS. VFS. LCS. LMS. LFS.
◫	MODERATELY COARSE TEXTURED LVFS. CSL. MSL. FSL.
⧄	MEDIUM TEXTURED L. VFSL. SIL.
⊠	MODERATELY FINE TEXTURED SCL. CL. SICL. SI.
■	FINE TEXTURED SC. C. SIC.
☰	SHALE & SILTSTONE
░	SANDSTONE
▵	UNCONSOLIDATED BEDROCK
▨	ORGANIC MATTER
▥	LIMESTONE
⬭	IRONSTONE



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EDSON AQUIFER TESTING PROGRAM
FIGURE 2A YATES PROFILE
March, 1969

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APPROVED BY
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PLAN No. 9-605A-E-5

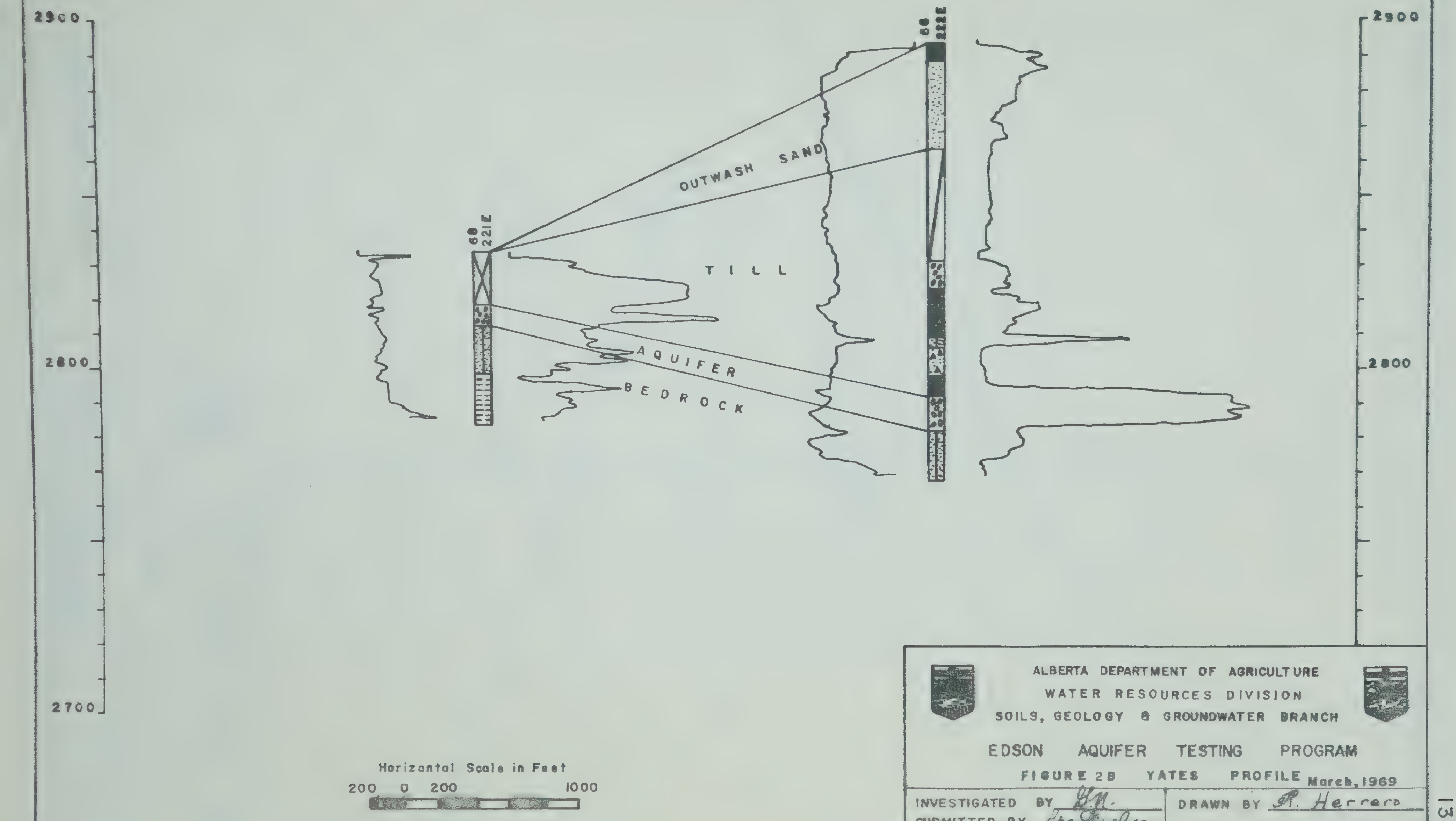

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FIGURE 2B YATES PROFILE March, 1969

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DRAWN BY R. Herrero
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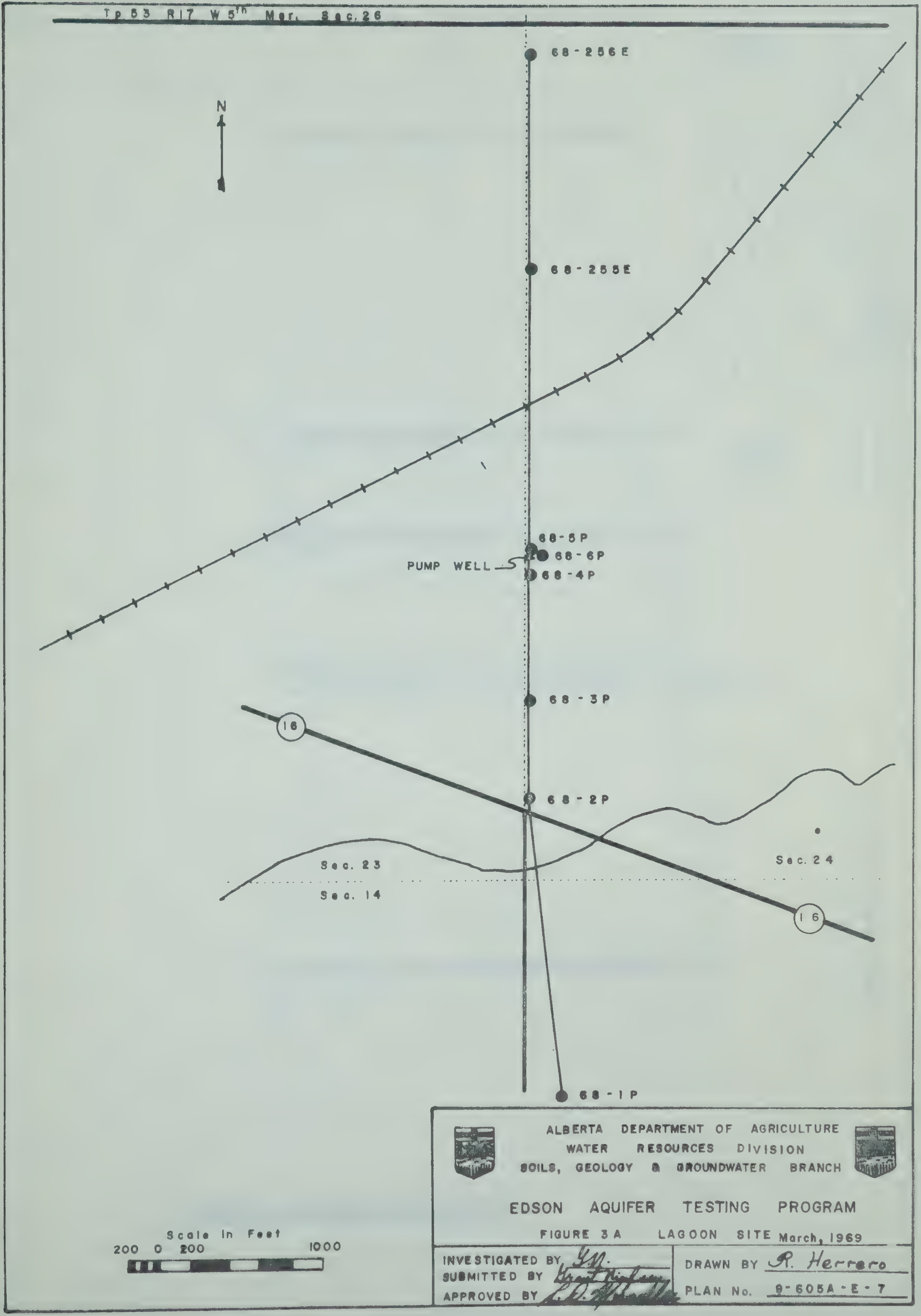

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FIGURE 3A LAGOON SITE March, 1969

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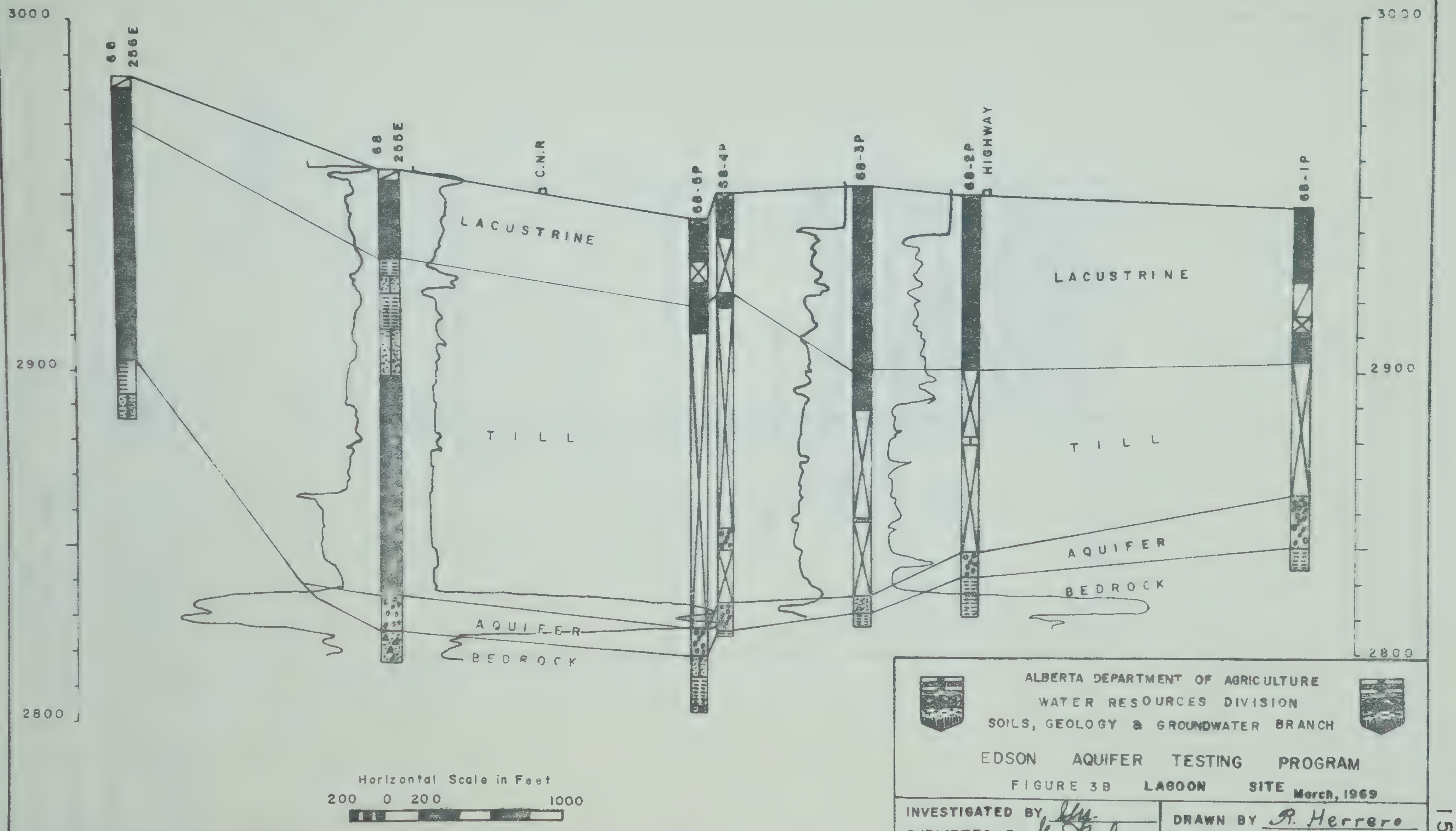

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FIGURE 3B LAGOON SITE March, 1969

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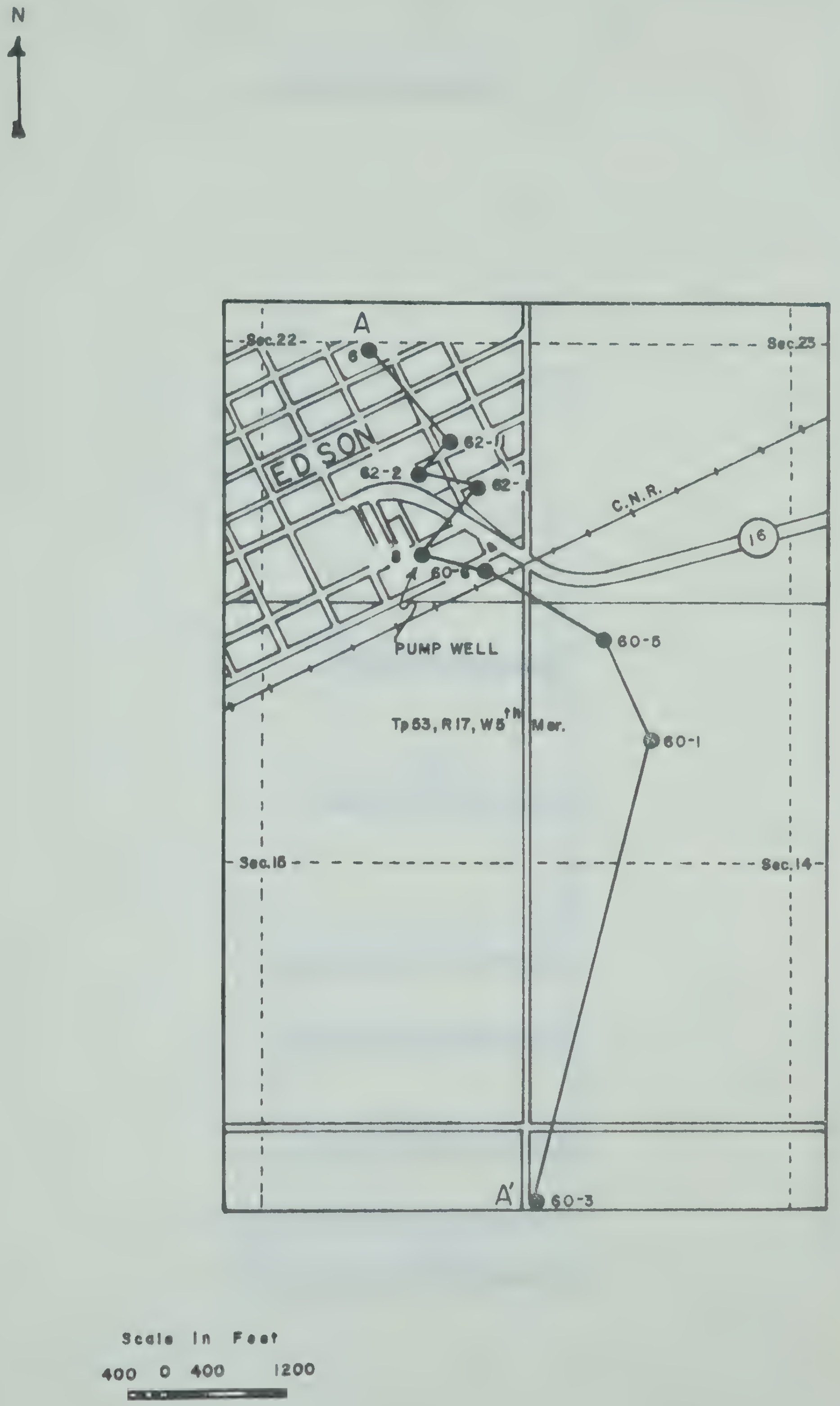

SOURCE: RESEARCH COUNCIL OF ALBERTA,
REPORT 68-1, PAGE 7.

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FIGURE 4A GOLF COURSE PROFILE March, 1969

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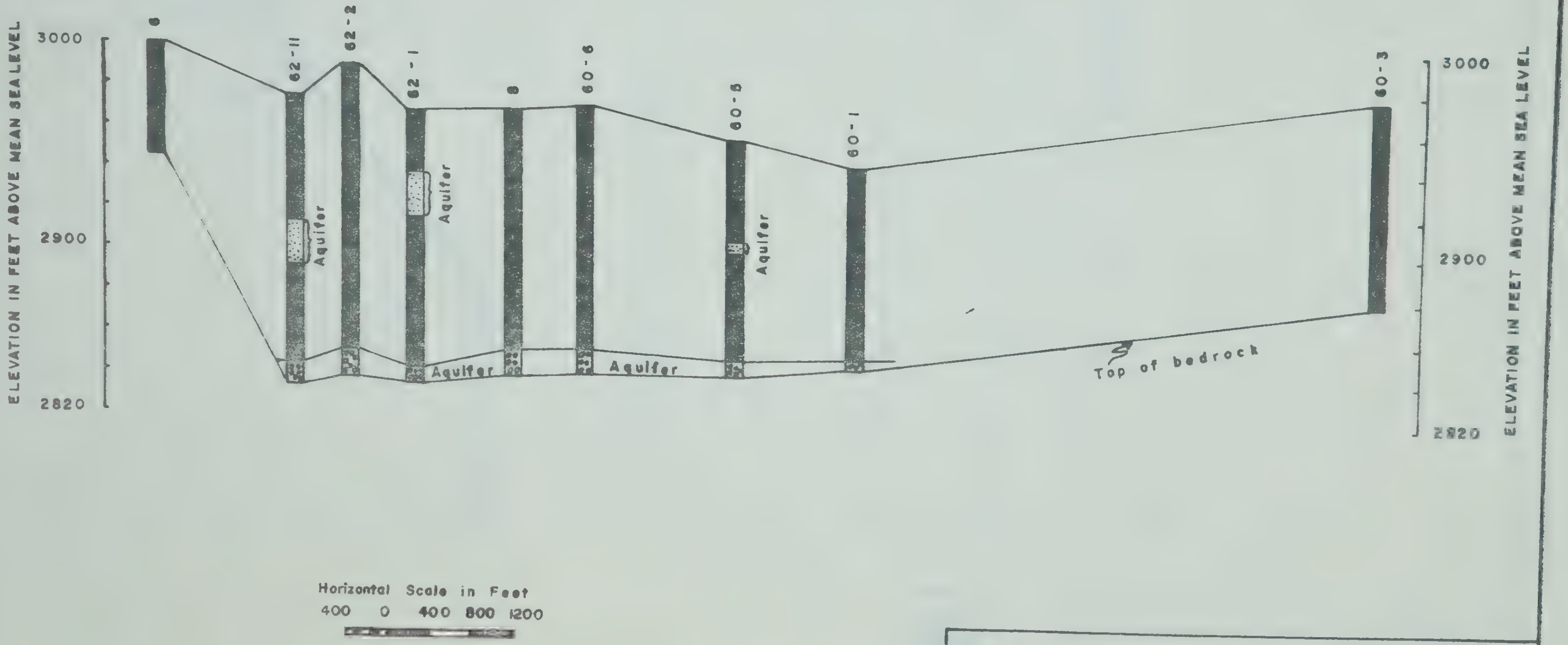

SOURCE, RESEARCH COUNCIL OF ALBERTA, REPORT 68-1, PAGE 6.

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EDSON AQUIFER

FIGURE 48 GOLF COURSE PROFILE March, 1969

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APPROVED BY COUNCIL

DRAWN BY R. Herrero
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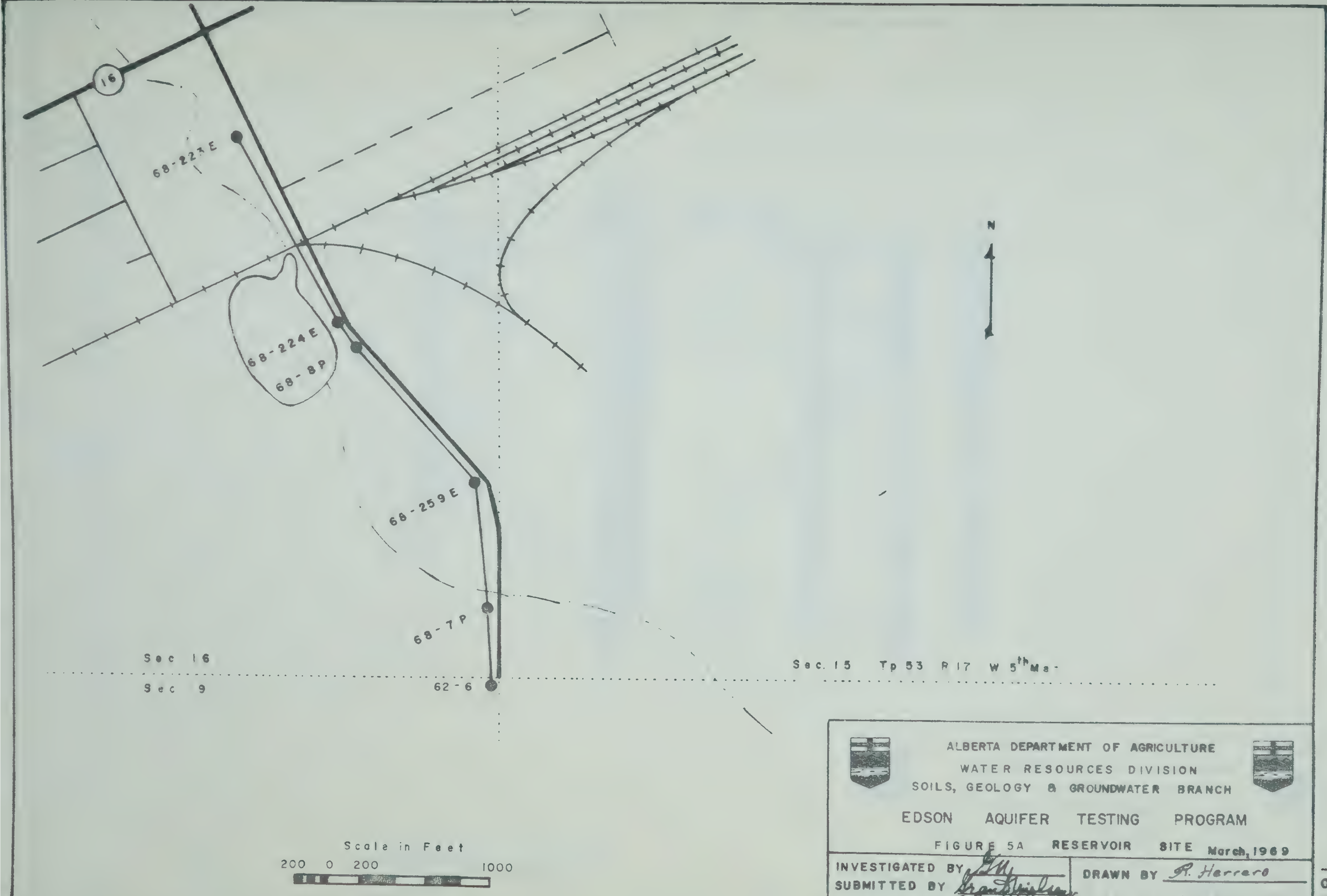

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FIGURE 5A RESERVOIR SITE March, 1969

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APPROVED BY	PLAN No. 9-605A-E-9

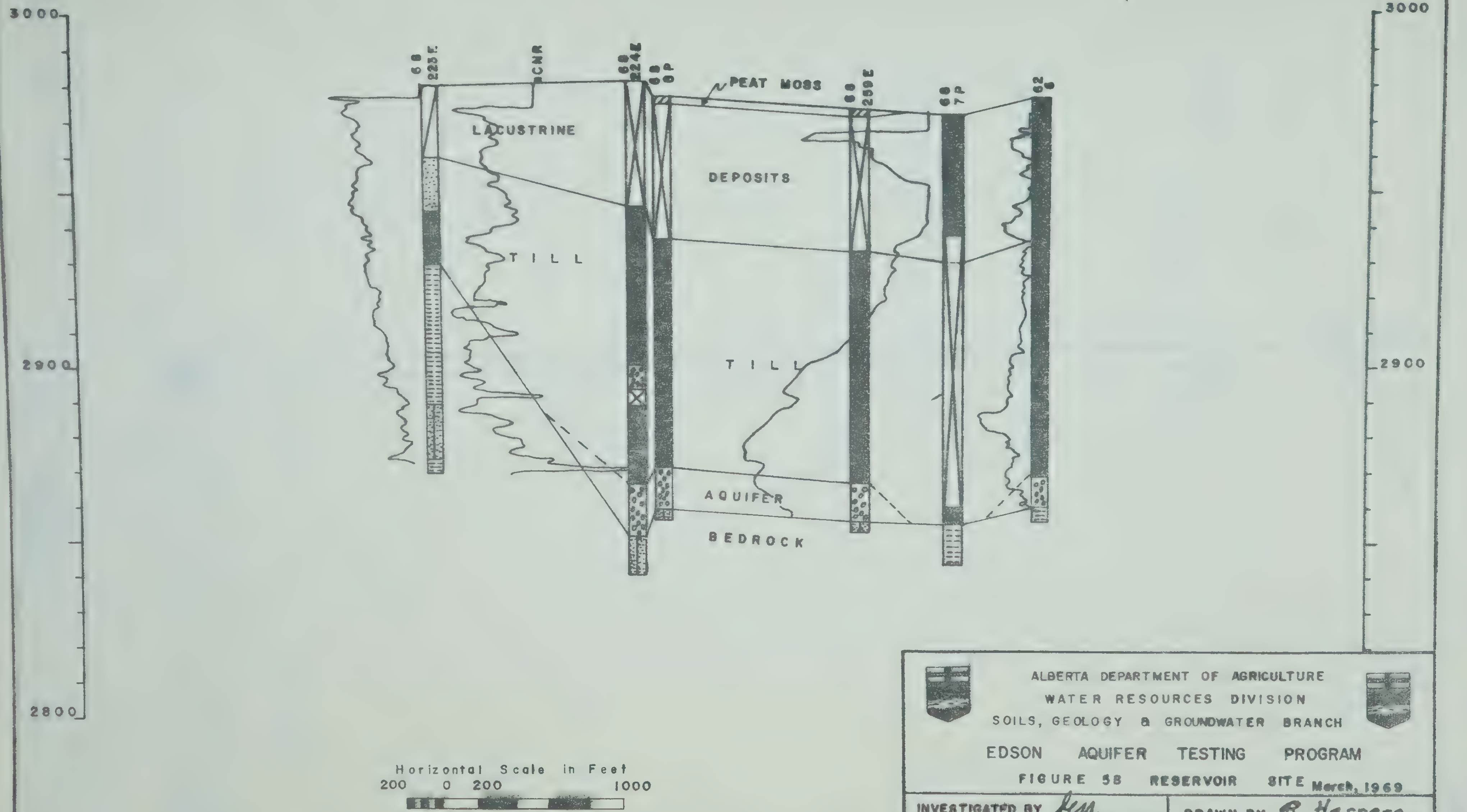

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FIGURE 58 RESERVOIR SITE March, 1969

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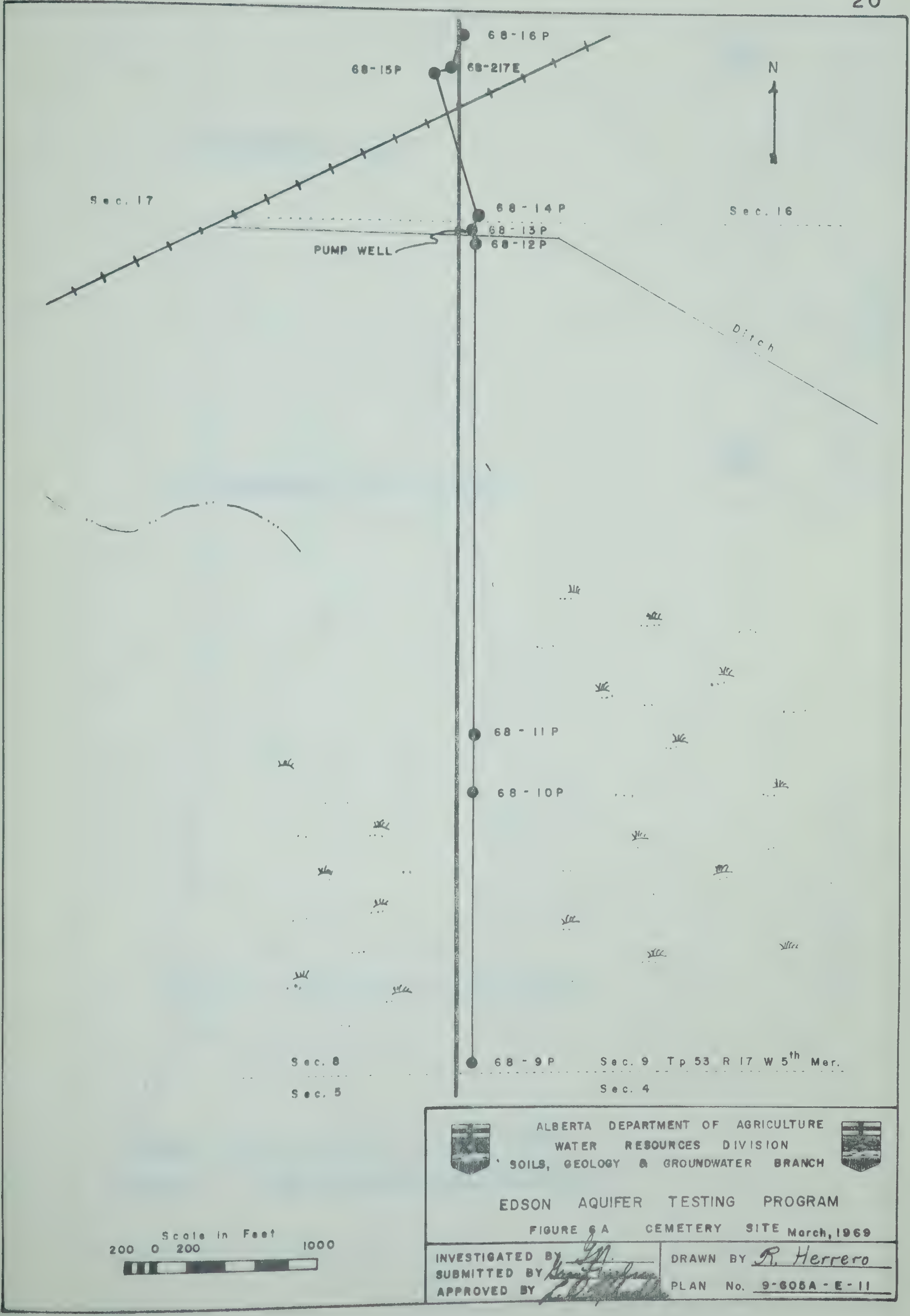

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FIGURE 6A CEMETERY SITE March, 1969

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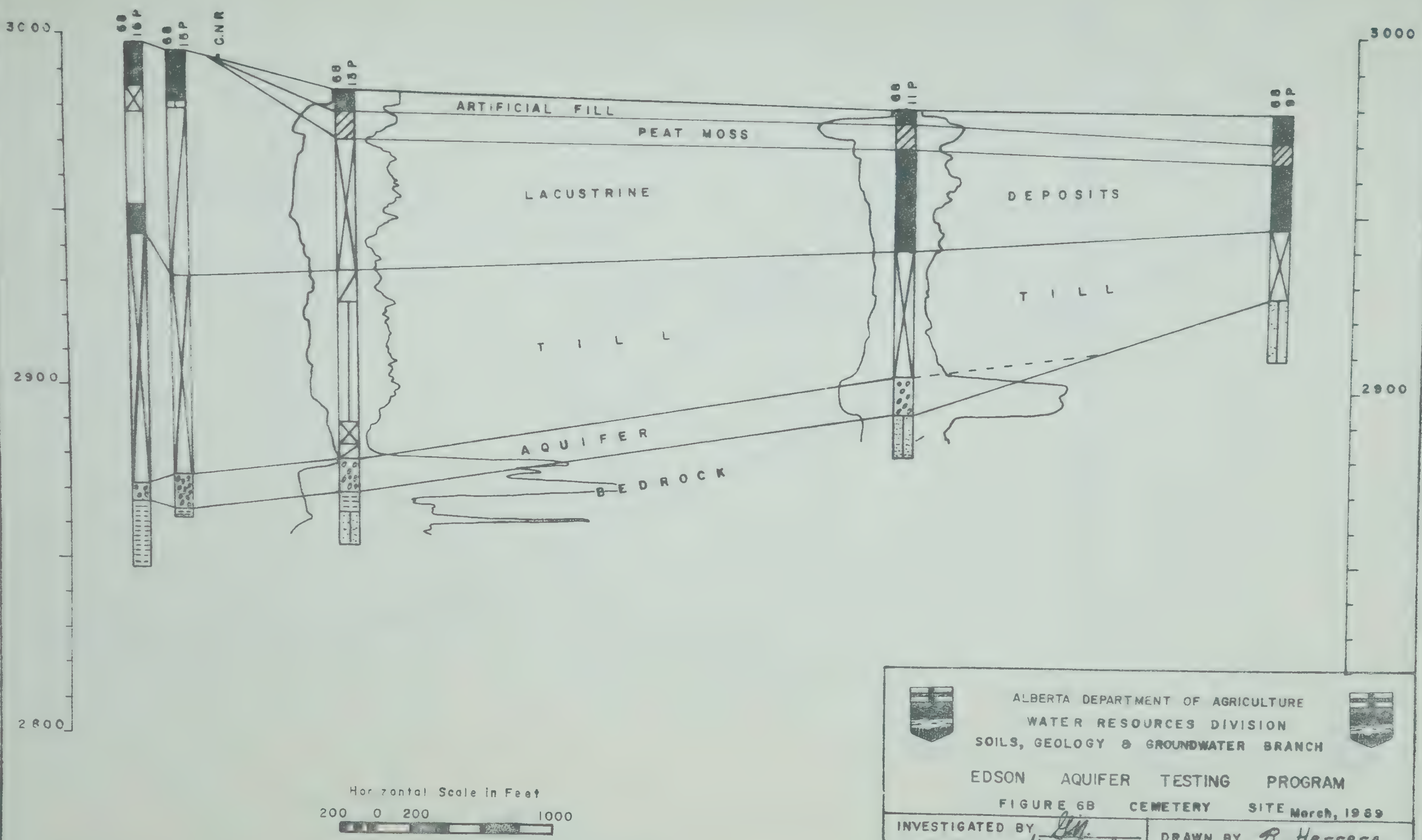

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FIGURE 6B CEMETERY SITE March, 1969

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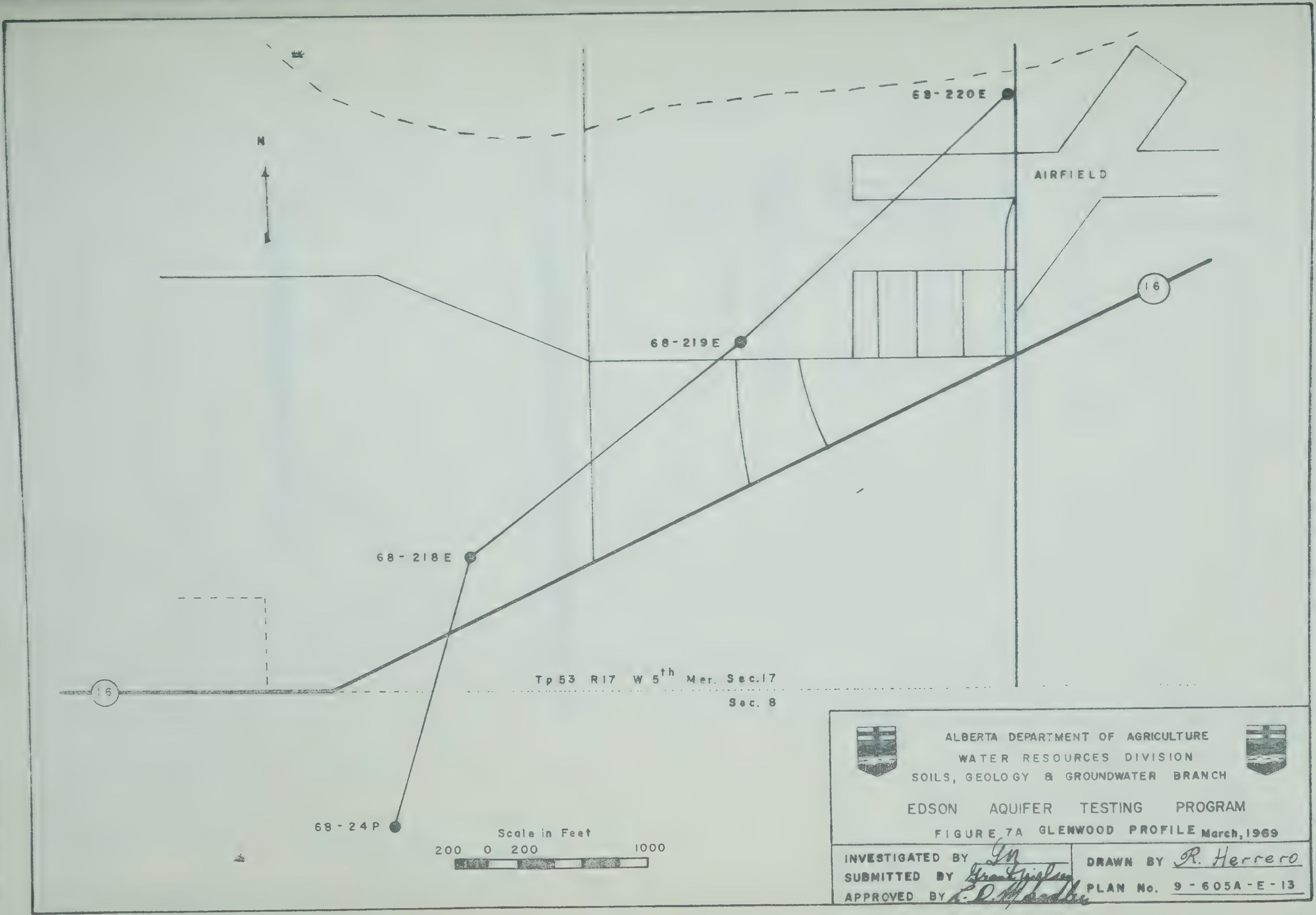

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FIGURE 7A GLENWOOD PROFILE March, 1969

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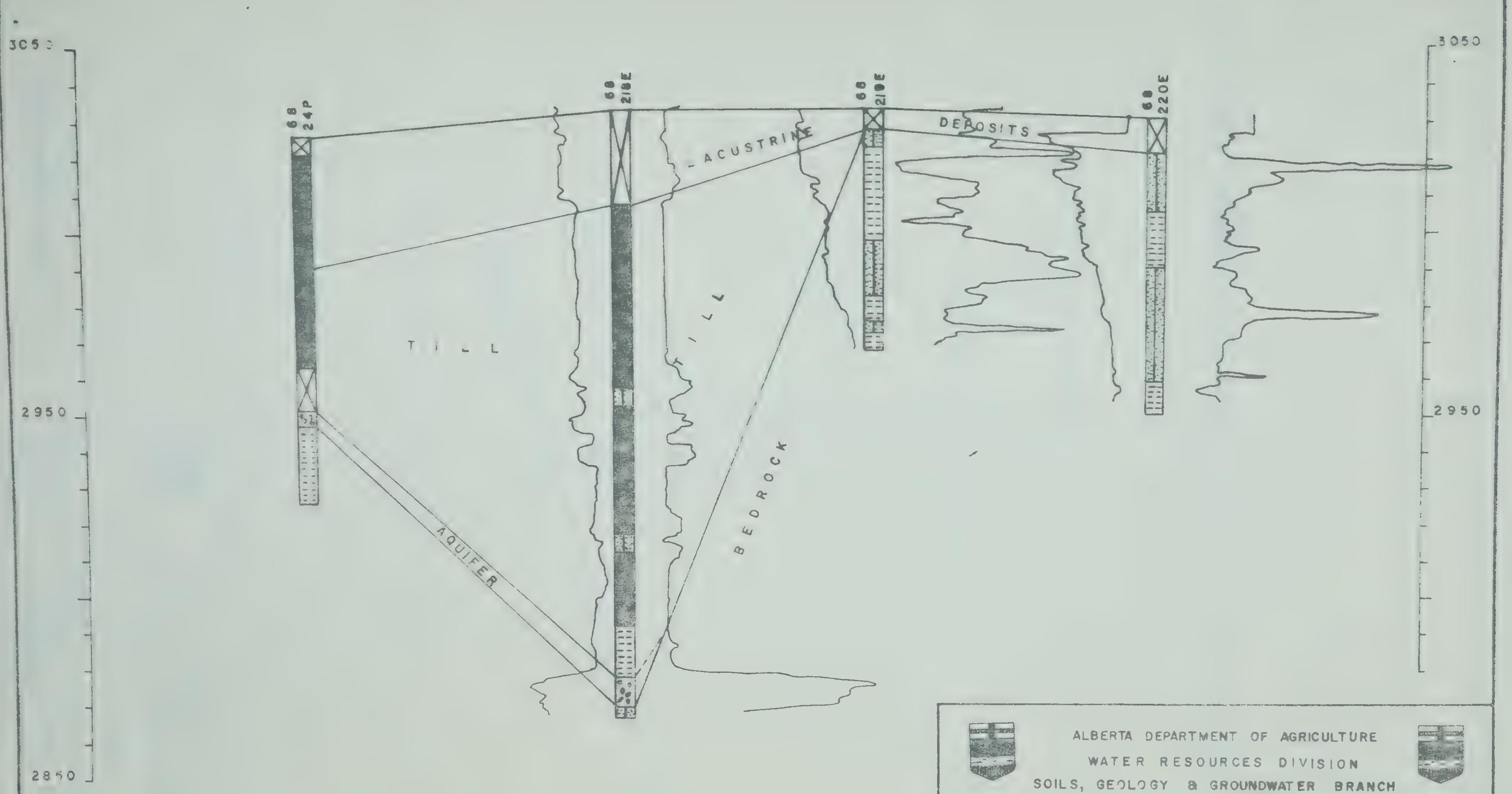

Horizontal Scale in Feet
200 0 200 1000

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FIGURE 7B GLENWOOD PROFILE March, 1969

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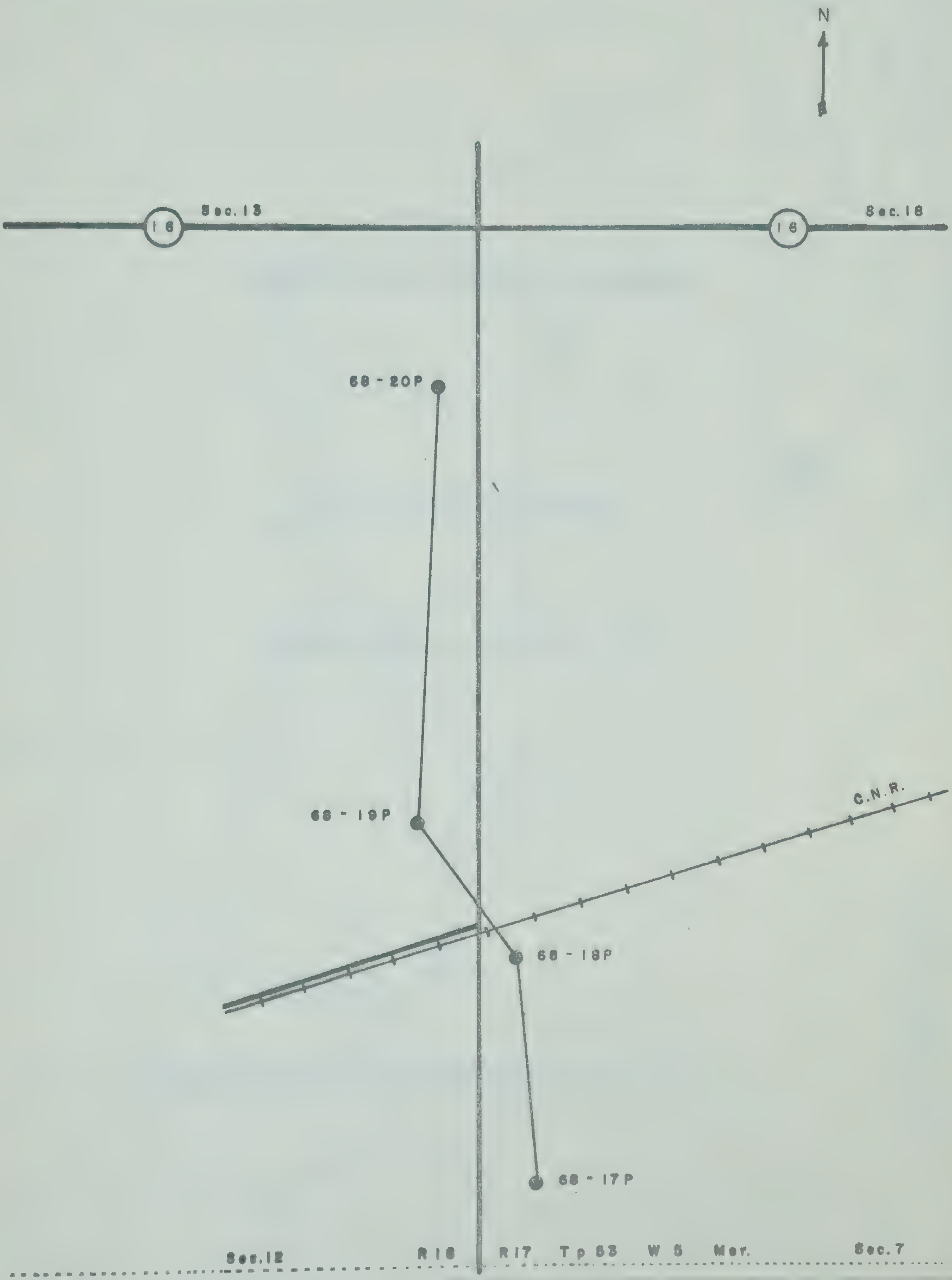

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FIGURE 8 A ANSEL PROFILE March, 1969

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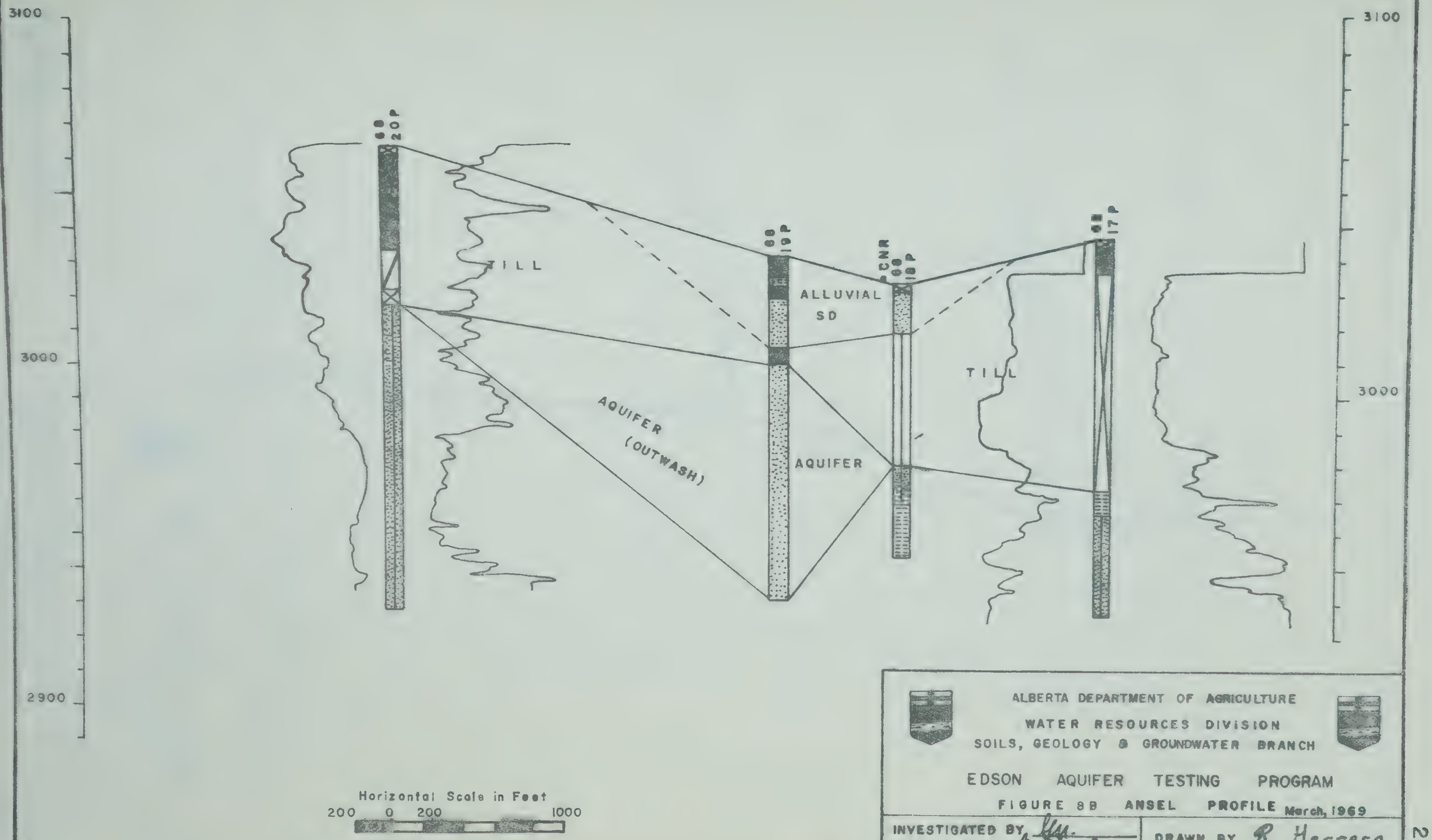

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FIGURE 8B ANSEL PROFILE March, 1969

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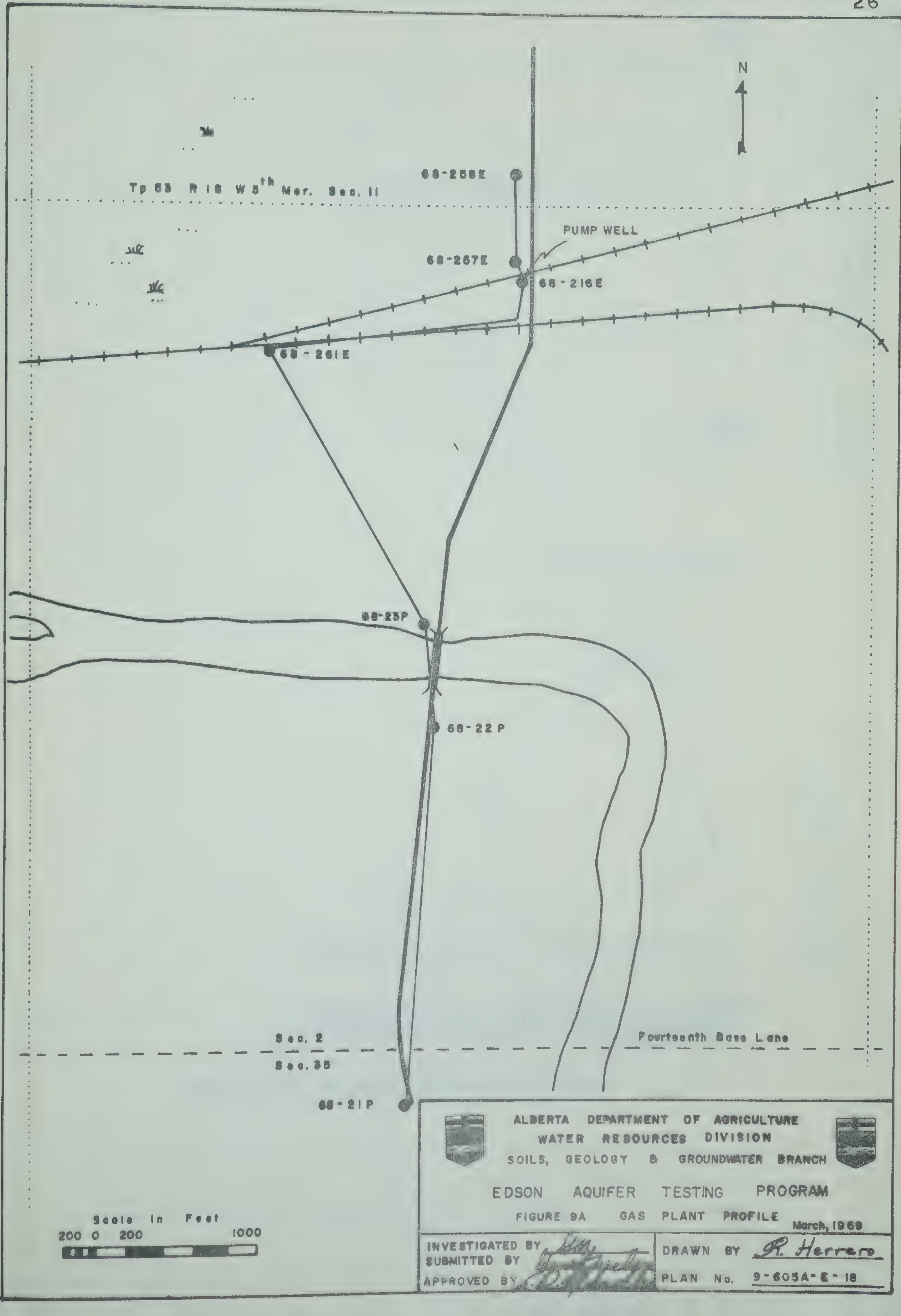

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FIGURE 9A GAS PLANT PROFILE

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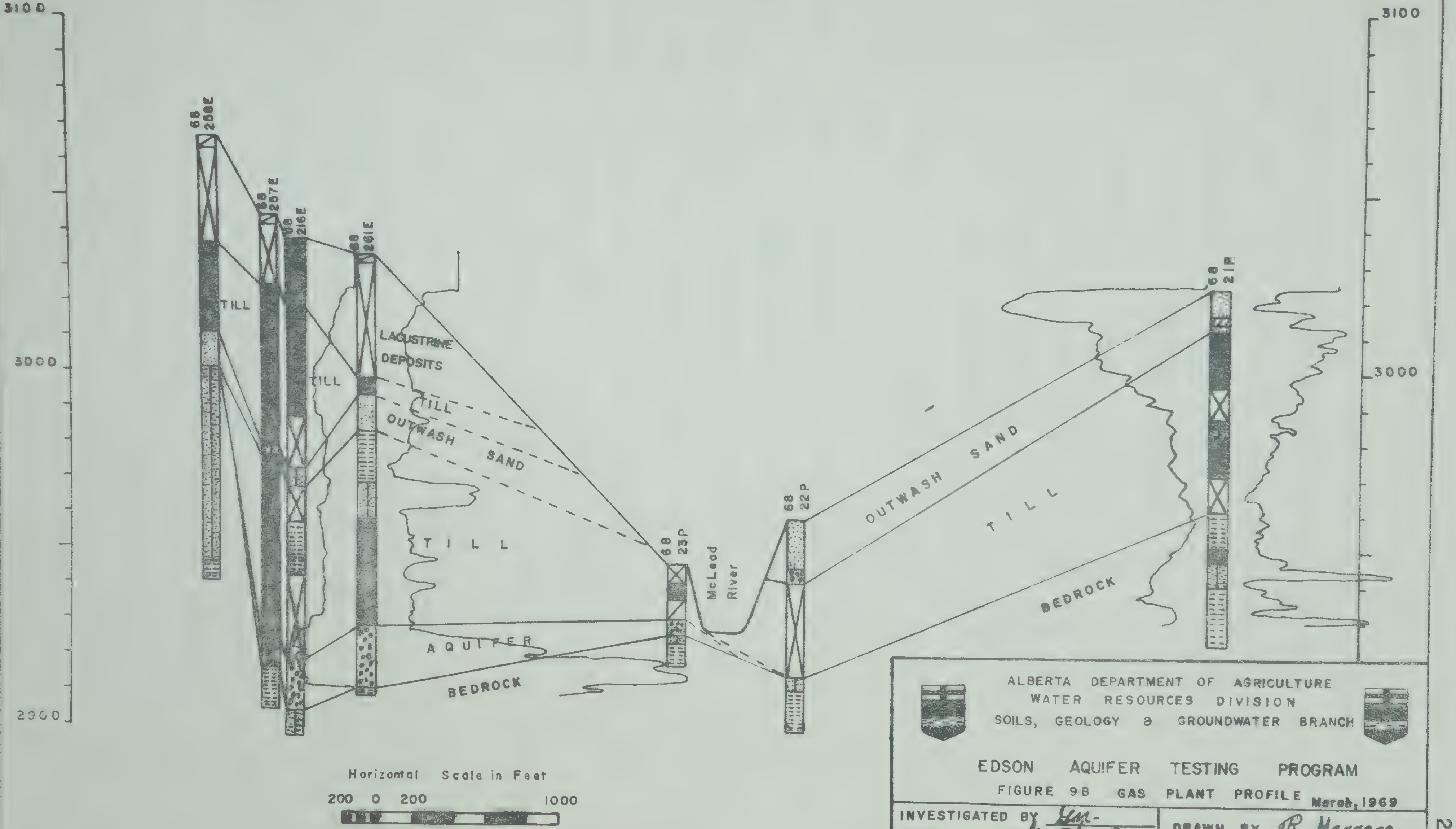

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FIGURE 9B GAS PLANT PROFILE March, 1969

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DRAWN BY R. Herrero
PLAN No. 9-605A-E-17

Locations of the pump well and observation wells in the Lagoon pump test are shown in Figure 3. The pump well was pumped at 50 gallons per minute for 4 days, from July 2 to July 6, 1968. Non-pumping level was 68.91 feet, with actual drawdown of 18.89 feet out of 47 feet of available drawdown. A barrier boundary was indicated by pump-test results 1080 feet west north-west of the pump well.

Figure 6 shows a plan of the pump well and observation wells on the Cemetary site. The pump well was pumped at 30 gallons per minute for 4 days, from July 25 to July 29, 1968. Non-pumping level was 80.87 feet and drawdown was 10.41 feet out of 24 feet available drawdown, corrected for barometric pressure changes.

Figure 9 shows the arrangement of pump well and observation wells on the Gas Plant road. The pumping rate was 25 gallons per minute, with an initial non-pumping level of 103.06 feet, and 7.01 feet of drawdown in 7 days out of 13 feet of available drawdown. Unfortunately the observation wells failed to respond in this test, as the extremely small head of water made their development impractical with the compressor which was to be used.

Pump test analysis yielded the coefficients of transmissivity and permeability shown in Table 1.

All drill holes for which records are available are shown on Figure 10. Figure 11 shows the configuration of the Edson aquifer, interpreted from these records. The "thalweg" is the line along the deepest portion of the channel.

Induced Infiltration Sites

The two sites where McLeod River crosses the Edson Channel (Sec. 2-53-18-W5, and Sec. 4-54-16-W5) were investigated as to their potential for induced infiltration. These were considered to be excellent locations for industrial development because of the abundant supply of high quality water which could be developed.

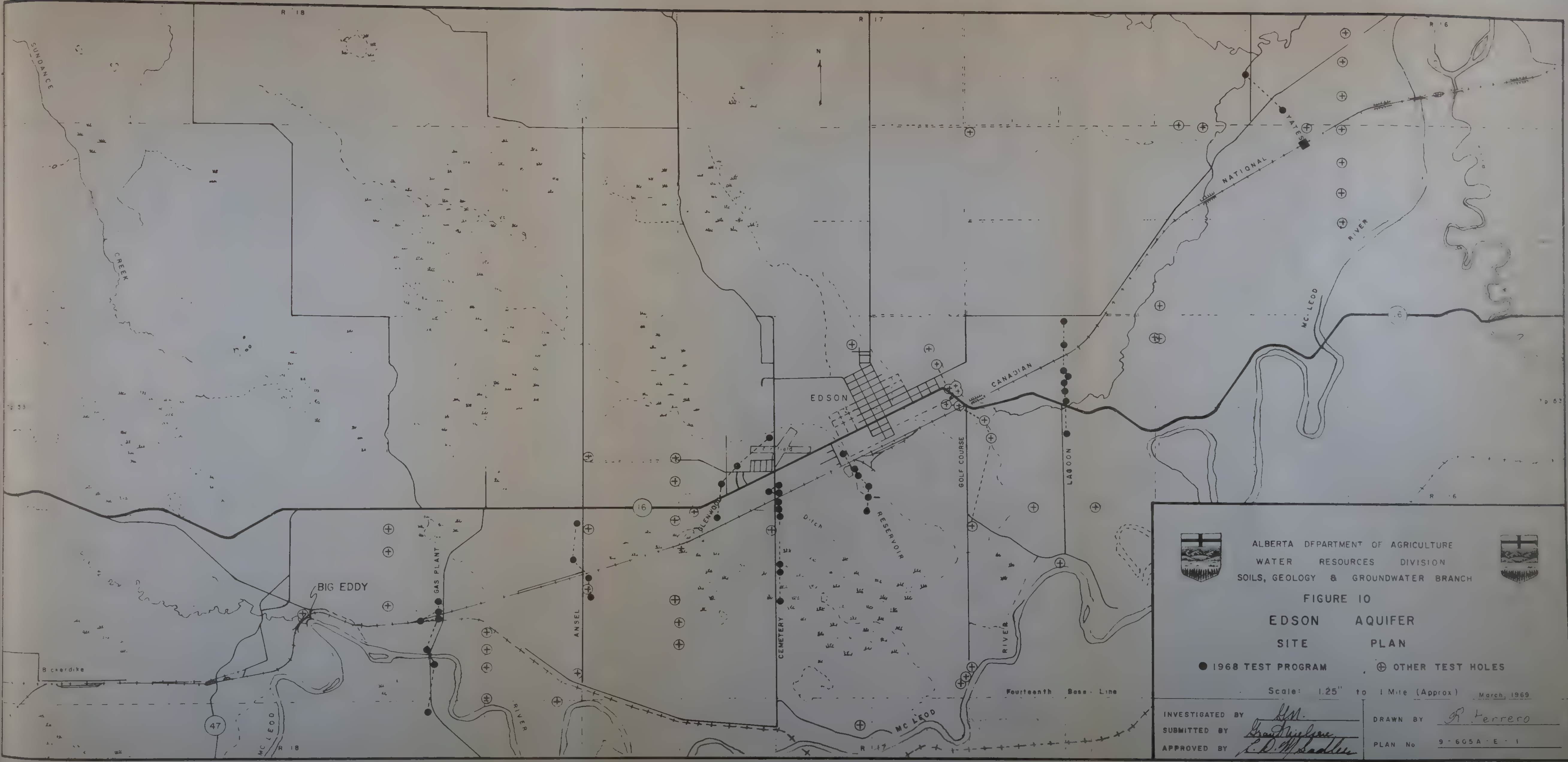

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FIGURE 10

EDSON AQUIFER
SITE PLAN

● 1968 TEST PROGRAM ⊕ OTHER TEST HOLES

Scale: 1.25" to 1 Mile (Approx) March, 1969

INVESTIGATED BY G.N.
SUBMITTED BY Grant Nielsen
APPROVED BY

DRAWN BY R. Ferrero
PLAN No 9-605A-E-1

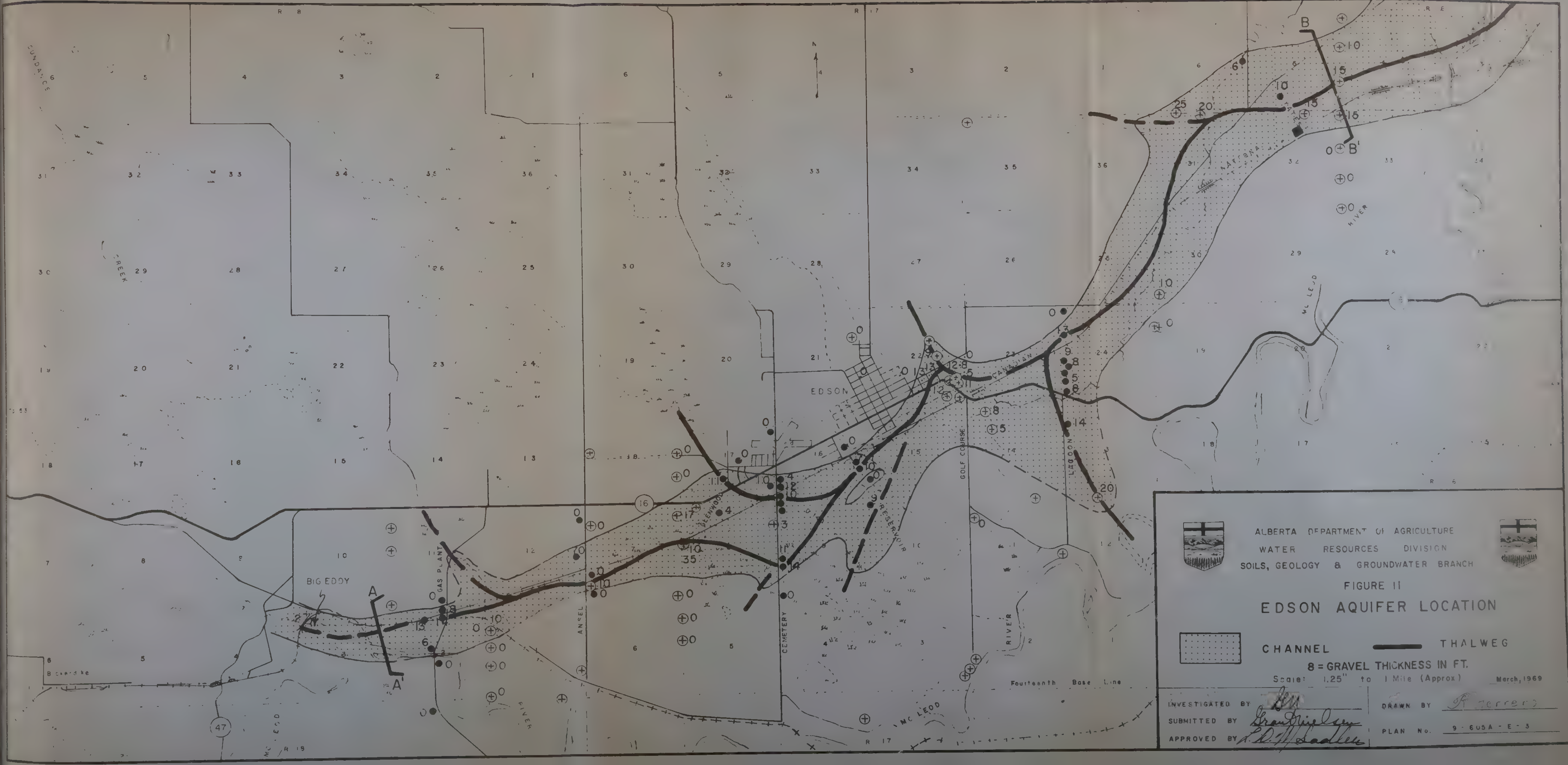

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FIGURE 11

EDSON AQUIFER LOCATION

▨	CHANNEL
▬	THALWEG

8 = GRAVEL THICKNESS IN FT.

Scale: 1.25" to 1 Mile (Approx) March, 1969

INVESTIGATED BY
SUBMITTED BY Gran Nielsen
APPROVED BY L.D.W. Sadler

DRAWN BY R. Ferrero
PLAN No. 9-605A-E-3

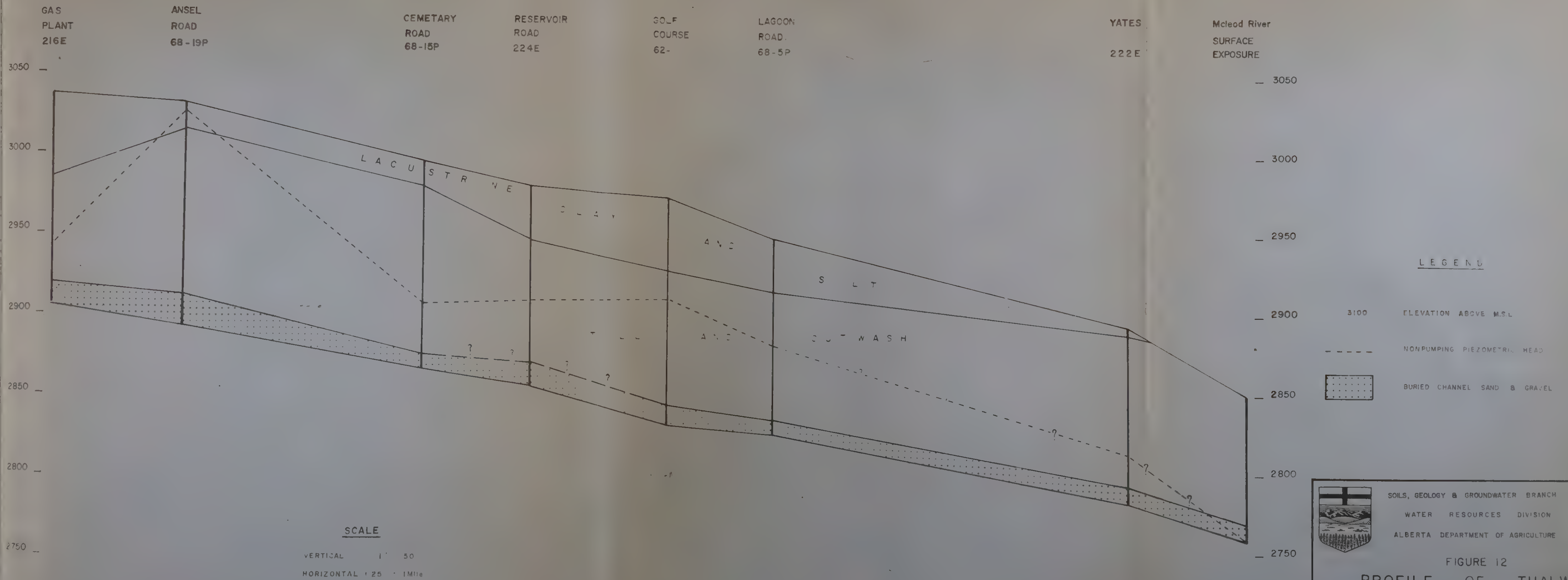

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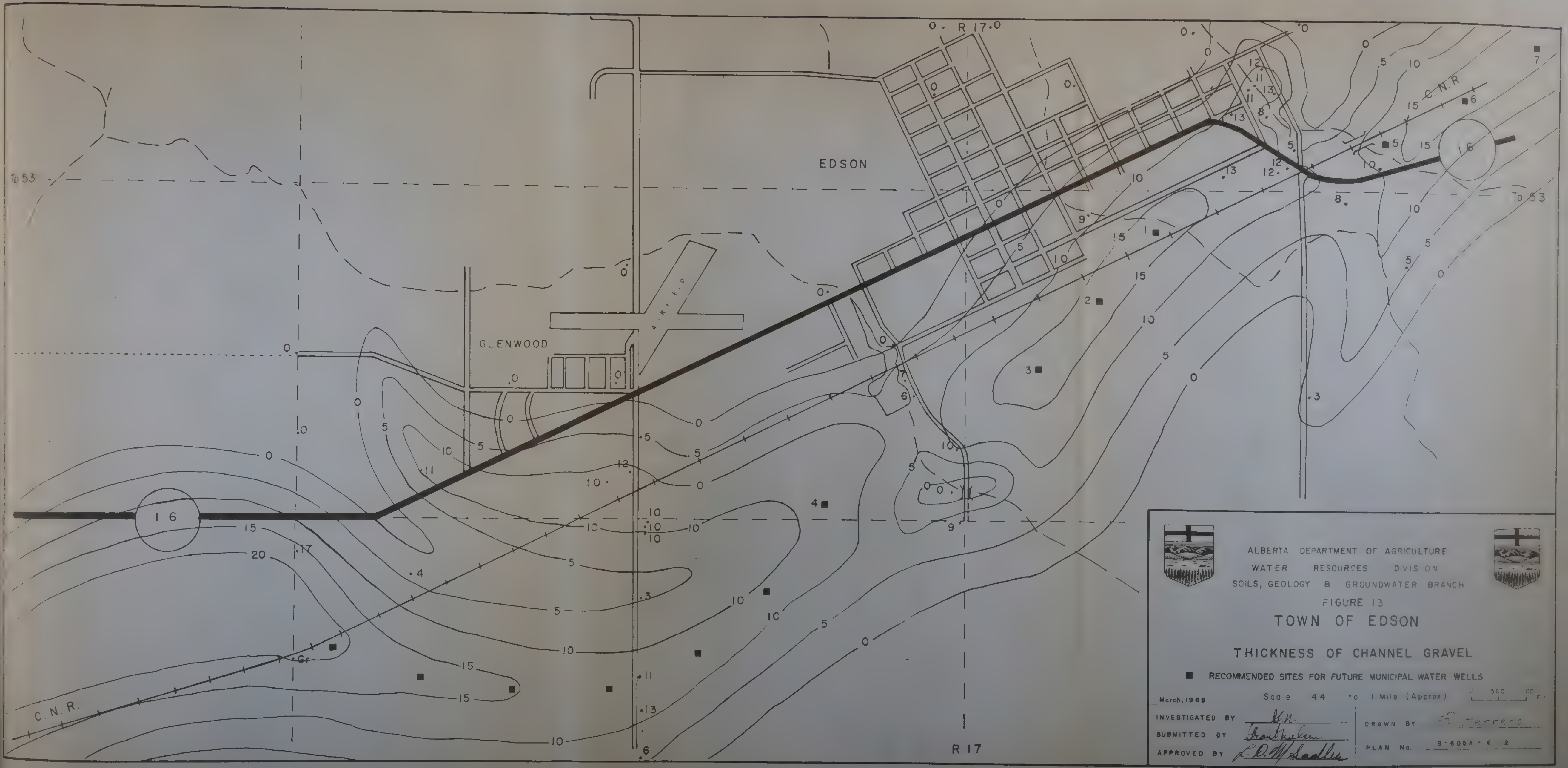
FIGURE 12

PROFILE OF THALWEG

EDSON CHANNEL

March, 1969

INVESTIGATED BY GM
SUBMITTED BY Grant Nyelsen
APPROVED BY L. D. McSoodlen
DRAWN BY R. Herrero
PLAN No. 9-605A-E-4



ALBERTA DEPARTMENT OF AGRICULTURE
WATER RESOURCES DIVISION
SOILS, GEOLOGY & GROUNDWATER BRANCH

FIGURE 13

TOWN OF EDSON

THICKNESS OF CHANNEL GRAVEL

■ RECOMMENDED SITES FOR FUTURE MUNICIPAL WATER WELLS

March, 1969

Scale 44' to 1 Mile (Approx)

INVESTIGATED BY G.N.
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PLAN No. 9-605A-E 2

Drilling results from Sec. 2-53-18-W5, (Figure 9A and B) along the Hudson's Bay Oil and Gas Co., private road suggested that the possibility of artificial recharge exists here. The top of the gravel in the lowest part of the channel is only about ten feet below river level. Yet non-pumping level in the channel at this point is 21 feet above the gravel. Therefore the elevation of the piezometeric surface decreases toward the river, and the groundwater is flowing from the channel into the river at this point under natural conditions. Once this area is pumped, however, and piezometric head drops to river level, further pumping will reverse the direction of flow and water will be induced into the aquifer from the river.

Hole 68-216E was pump-tested at 25 gallons per minute for 7 days, from February 12 to February 19, 1969. Transmissivity was calculated to be 18,300. A recharge boundary effect was observed at 8500 minutes, when drawdown was 7.01 feet. Although this water level is 3 feet higher than river stage directly south, it is somewhat lower than river stage a short distance upstream, where the hydraulic connection appears greater between the well and the river.

Certain aquifer coefficients obtained from the pump tests to the east have been used and assumed to be representative since observation wells failed to respond. This test was analysed by the technique used by Vanden Berg and Lennox (1968), as is explained in the section on Well Field Development (Formulas 4, 5 and 6). With allowance for both barrier and recharge boundaries, safe yield here is 96 gpm for a single well. Aquifer parameters used here are:

Transmissivity T = 18,300 (from this pump test)
Aquifer width D = 2,700 ft.
Aquitard thickness b' = 110 ft. (from drill logs)
Aquitard vertical permeability P' = 0.128 (maximum value found eastern sites)
Storage coefficient S = 1.1×10^{-3} (average for other 3 sites)
Effective well radius r = 1.5 ft.
Leakage coefficient B = 3.96×10^3

A high value of P' was used because of the presence of a layer of permeable outwash sand in this area. Any industry wishing to establish here must do very careful testing of the site. Since the channel is only 2700 feet wide, wells should be so placed as to minimize barrier boundary effects, yet maximize induced infiltration.

In well 68-216E, outwash sand was found at 40 to 50 feet depth. It is saturated and has a non-pumping level of 30 feet. It also has some potential as an aquifer, although small compared to that of the Edson Aquifer.

The best site in this area for an artificial induction well is in NE -3-53-18-W5, as the channel here has a more direct hydraulic connection with the river than at the test-pumping site.

The eastern site was examined by field inspection. The channel gravel was found to outcrop in the banks of McLeod River above present river level, where numerous springs, seepages and slump features occur. Since the gravel is higher in elevation than modern river level, no artificial recharge is possible.

Aquifer Potential

In order to keep computations as simple as possible, values used in this section have been averaged from the available data.

Bennett's flow-net analysis (Ferris, et al, p. 139-144) was used to calculate groundwater flow from bedrock into the channel. The formula used is:

$$Q = \frac{N_f}{N_d} Th, \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(1)$$

where Q = discharge, in gallons per day
N_f = number of flow lines
N_d = number of equipotential drops
T = transmissivity, in gallons per day per foot
h = total potential head, in feet

The drainage basin which contributes groundwater to the Edson aquifer is of irregular shape, and hence a number of individual "Q"s" had to be calculated, then summed. A transmissivity of 1280 was obtained by averaging values for six bedrock wells. Total daily groundwater contribution from bedrock to the channel was found to be 7,680,000 gallons under natural conditions. The portion of the channel under consideration is shown between large parentheses A-A' and B-B' in Figure 11.

P', the coefficient of vertical permeability of the confining beds over the aquifer is given by

$$P' = \frac{T\, m'\, (r/B)^2}{r^2} \quad \text{(Walton, a, p.7)} \ldots\ldots\ldots\ldots\ldots\ldots\ldots(2)$$

where P' = coefficient of vertical permeability, in gallons per day per square foot
T = Transmissivity of aquifer, in gallons per day per foot
r = distance from pumped well to observation well, in feet
m' = thickness of confining bed through which leakage occurs, in feet
B = leakage coefficient

The value of P' was calculated for the two aquifer tests where sufficient data were available (.077 and .006); the average of these two values with that found by Vanden Berg and Lennox in 1968 (.128) was used in the ensuing calculations.

The quantity of water percolating vertically to the channel was then calculated by:

$$Qc = (P'/m')\,\Delta h\, Ac \quad \text{(Walton, b. p.22).......(3)}$$

Where: Qc = leakage through confining beds, in gpd.
P' = defined above
m' = defined above
Ac = area of confining bed through which leakage occurs, in sq. ft.
Δh = difference between the head of the aquifer and in the = source bed, in feet

In the case of the Edson aquifer, the average figures used were:

P' = 0.07 gpd/ft.^{2}
m' = 115 feet
Δh = 65 feet
Ac = 11.1 square miles
Qc = $(0.07/115)\ (65)\ (11.1 \times 5280^2)$
= 12,200,000 gpd.

Therefore, total daily recharge to the channel is about 7,680,000 + 12,200,000 = 19,880,000 gallons, of which 38% is seepage from bedrock, and 62% is vertical percolation of precipitation.

Total annual recharge is $19{,}880{,}000 \times 365 \div 6.24 = 1.16 \times 10^8$ cubic feet. Over the 279 square mile drainage basin which recharges the 11.1 square mile strip of aquifer, this is 1.8 inches of recharge annually, or about 8% of annual precipitation.

A rough hydrologic budget can be established as follows, all figures being in inches of water:

Precipitation = Evapotranspiration + Runoff + Groundwater discharge
22" = 15" + 5" + 2"

The many swamps and small lakes in the area are evidence that more than enough water is present to recharge the aquifer at its maximum rate.

The only means of increasing the recharge rate is to increase the Δh of the above formula. As development of the aquifer progresses, a general drawdown of piezometric head will result in greater Δh. The head in the source beds is conservatively estimated at 10 feet below surface. That of the aquifer averages 75 feet, the difference being 65 feet. Should the head of the aquifer be drawn down eventually to the top of the aquifer, the difference, "Δh" would become 116-10 = 105 feet. This would be an increase of $\frac{105 - 65}{65} \times 100 = 77\%$, and the vertical recharge rate would increase proportionately.

Stanley Associates Engineering (p.4) estimate average daily water consumption at 251,000 gallons per day in 1972. This is only 1.3% of average daily recharge to the aquifer. At present rates, therefore, no problem of aquifer depletion should exist, provided that individual wells are adequately spaced and not over-pumped.

Well Field Development

The area immediately south and east of Edson will be developed into a well field in the near future for municipal use. Extensive exploitation of the channel to the west and east will probably take many years, as these areas will await industrial development. This section will discuss only that portion of the channel adjacent to the town of Edson.

At Edson, the channel is approximately 4000 feet wide, has an average transmissivity of 12,750 gallons per foot per day, and the storage coefficient averages 1.1×10^{-3}. Average available drawdown is 44 feet. The coefficient of vertical permeability is 0.07 gpd/ft.^{2}, confining bed thickness is 115 ft., and B is 3.4×10^3.

To calculate all self-caused drawdown in a pumped well on the centerline of the channel, the following formula is used.

$$S_f = \frac{Q}{4\pi T} W(u_w, r_w/B) + 2 \sum_{k=1}^{\infty} W(u_{kd}, kD/B) \quad \ldots\ldots\ldots(4)$$

in which r_w is the effective well radius (Vanden Berg and Lennox, 1968), and

$$\frac{S}{Q} = \frac{114.6\ W(u)}{T} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(5)$$

$$U = \frac{2242\ r_w{}^2 S}{Tt} \text{ (Walton, b. p.19)} \ldots\ldots\ldots\ldots\ldots\ldots\ldots(6)$$

$$= \frac{(2242)\ (1 \times 1)\ (1.1 \times 10^{-3})}{(1.27 \times 10^4)\ (10^7)}$$

$$= 1.94 \times 10^{-11}$$

Now, to calculate the first term, or real well contribution to specific drawdown, use is made of standard tables of W(u) vs. U; W(u) = 24.07, and r/B = 2.94×10^3.

Then $\frac{S}{Q} = \frac{(114.6)\ (24.07)}{(1.27 \times 104)} = 0.2175$ ft./gal.

For the image well contributions to specific drawdown, the second term of Formula 4 is calculated k times until individual image well drawdowns become less than or equal to 0.01.

Accordingly, total drawdown per gallon pumping rate is therefore:

0.2175 + 0.0094 + 0.0018 + 0.0004 = 0.2291.

Since average total total S = 44 feet, $Q = \frac{44}{0.2291} = 192$ gallons per minute.

This is the safe pumping rate for 20 years if there were one pumping well only, taking into account the effects of image wells due to barrier boundaries. When a second well is drilled and pumped, the effect of its drawdown on the first real well, plus the effect of each of its image wells on the first real well, and vice versa, must be taken into account. For an entire well field, this becomes extremely tedious and complex, and should be analysed on a computer.

Vanden Berg and Lennox (1968) did so, using parameters from one pump test only, conducted on the Golf Course Profile (Figure 4). Their safe yield for one well was 250 gpm, using the above method of analysis. This report found a safe yield of 192 gpm, averaging well parameters for 3 pump-test sites, so that this average value is much more realistic.

The safe yield of each actual well drilled will deviate to some extent from the average value. Inasmuch as the 192 gpm of this report is 77% of the 250 gpm calculated by Vanden Berg and Lennox and the relationship is linear, it is suggested that their graph of well yield vs. number of wells be used to design the well field, but with yields reduced to 75%. This is done in Figure 14.

For example, using a spacing of 1500 feet, 21 wells could be drilled in a six mile length of channel. Average safe yield per well would be 112 gpm, and total safe yield is 2150 gpm, or 3,100,000 gpd. (Figure 14). This is 31% of daily recharge into the six mile strip of aquifer, and adequate for all potential industrial requirements foreseen by Stanley Associates Engineering (page 5) except for a pulp and paper plant.

Wells near the ends of the well field can be pumped at higher rates than those in the center. This is because of less interference between wells at the ends. Pumping rates for wells spaced at approximately 1500 feet over a six mile length of channel are shown in Figure 15, related to distance from the center of the well field.

A much higher percentage of the daily recharge could be utilized through drilling of a large quantity of closely spaced wells. This is not recommended however, as their individual yields would decrease proportionately, and the additional cost would not be justified.

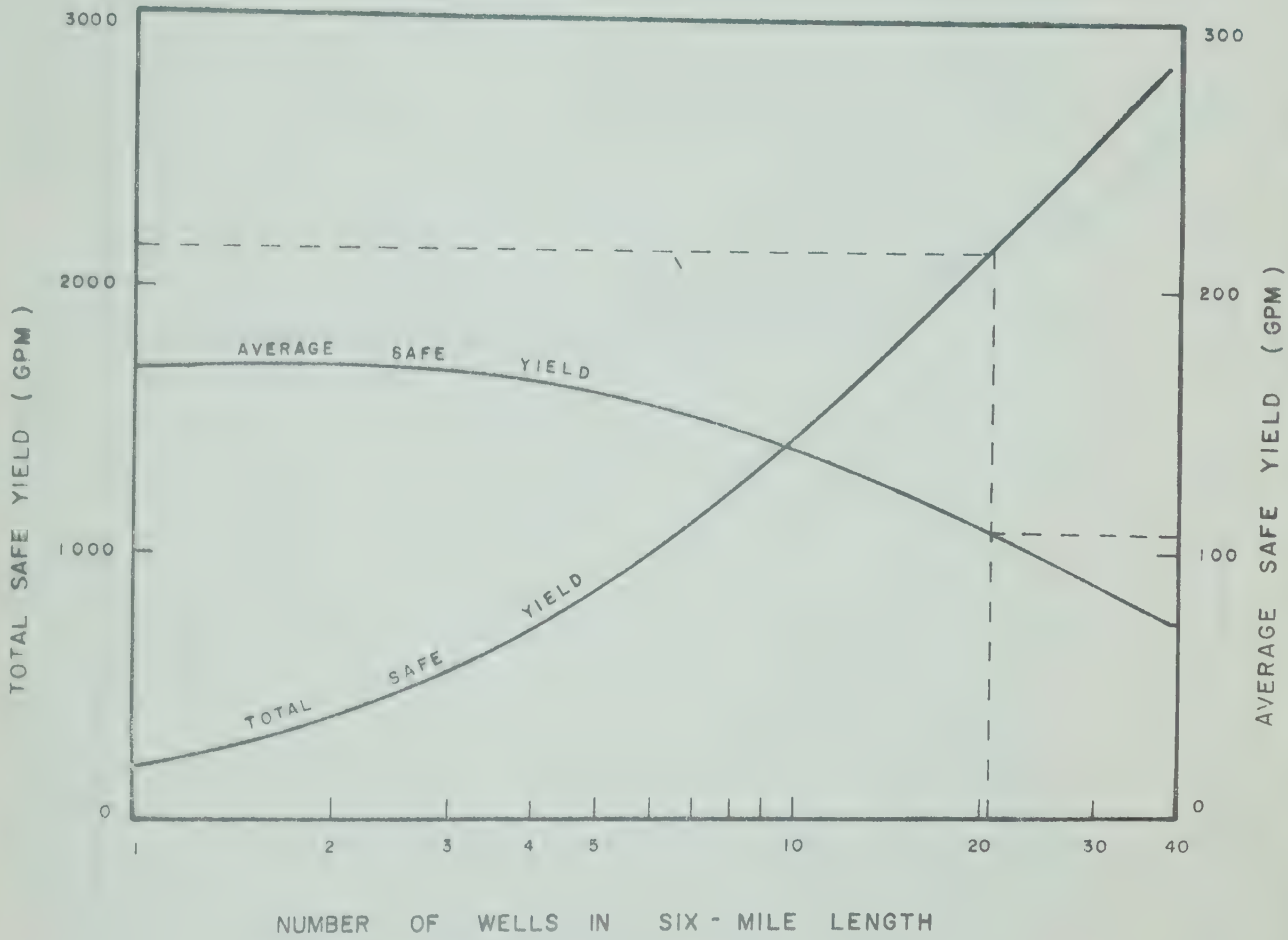

FIGURE 14. RELATIONSHIP OF WELL SPACING AND WELL YIELD

AFTER: VANDEN BERG AND LENNOX (1968)

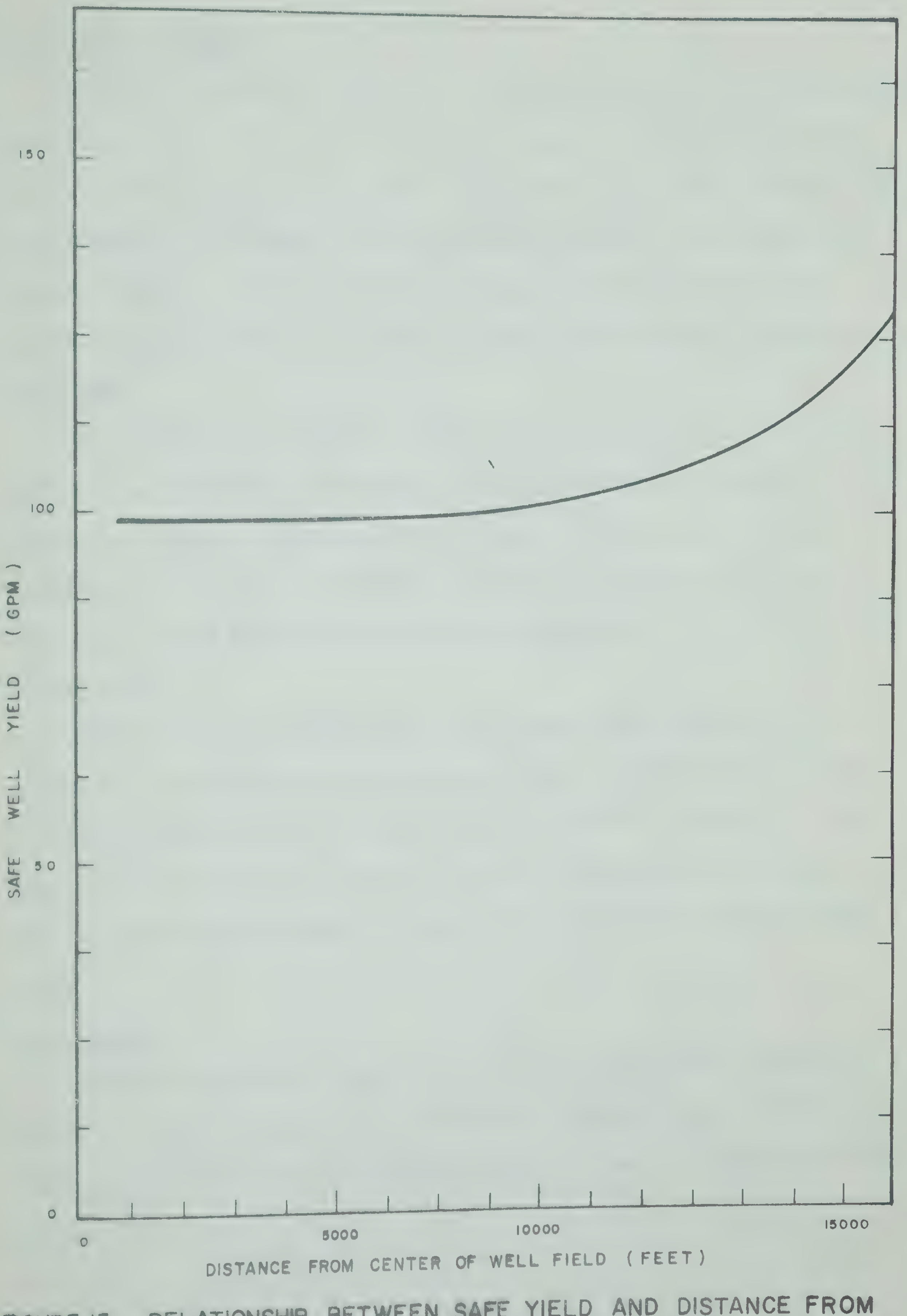

FIGURE 15. RELATIONSHIP BETWEEN SAFE YIELD AND DISTANCE FROM CENTER OF THE WELL FIELD

AFTER: VANDEN BERG AND LENNOX (1968)

Glenwood Water Supply

Well 68-13P, near the north end of the Cemetary Profile was pump-tested at 30 gallons per minute. Its transmissivity was calculated to be 12,200 igpd/ft. Excluding initial well loss, available drawdown was 16 feet. Over 4 day pump-test, no boundary conditions were observed in the pumping well. Its safe yield for a 20 year life is 100 gpm, ignoring possible future barrier boundary effects. As a safety factor, 50 gpm could be considered a safe yield.

The unincorporated village of Glenwood immediately north has a population of approximately 1200 people. Their daily water requirement, at 50 gallons per capita is 60,000 gallons. Yield from this well at 50 gpm is 72,000 gallons daily, so the village could be just supplied from this one well. Less than ½ mile of pipeline would be necessary from the well to the village itself.

Expansion of this system along the channel should follow the same pattern as outlined for the town of Edson above. Additional wells should be drilled along the center of the channel at 1500 foot intervals as needed, preferably to the west from well 68-13P. Developing to the west will minimize interference between the Edson well field and the Glenwood well field.

Water Quality

Several samples were taken from each of the pump-tested wells for chemical analysis. None of the constituents analysed exceeded acceptable limits at any of the sites, except for iron in one well. Results are shown in Table 2.

TABLE 2 - Chemical Quality of Groundwater

Constituent	U.S. Upper limit (ppm)	Alberta Upper limit (ppm)	14-8-53-17	15-2-53-18	13-9-53-17	5-24-53-17
Total Solids	1000	2000	674	582	576	574
Ignition loss	--	--	124	42	66	98
Hardness	--	--	282	105	183	127
Sulphates	250	800	131	100	78	34
Chlorides	250	500	2	2	2	0
Alkalinity	--	--	466	417	456	462
Nitrite	--	--	0	0	0	0
Nitrate	10	10	0	0	0	0
Iron	0.3	0.3	6.80	0.03	0.02	0.0
Fluoride	1.5	1.5	0.14	0.53	0.59	0.20
Soda	--	675	--	330.7	289.4	355.1
Temperature	--	--	41°	40°	41°	41°

The first analysis shown in Table 2 is from Well 68-24P which is bottomed in terrace gravel, somewhat higher in elevation than the channel itself. (See Figure 7). Quality of water from this source is somewhat poorer than that of the other wells, but still within acceptable limits except for the abnormal iron content. In other wells, water quality improved with pumping, so it is probable that this one will also improve.

Total solids is the weight of the solid material remaining when a known quantity of water is evaporated in an oven. Results are considered accurate only within about 5 per cent.

Ignition loss is the further loss of weight by heating the sample to a dull red color. It is measured only as a check on the accuracy of the analytical procedure, and has no further significance.

Hardness is quite relative, since what would be considered as hard water in one area would be termed soft in another. In Alberta, water containing 50-100 ppm is termed moderately soft, 100 - 200 ppm is moderately hard and over 200 ppm is hard. It will be seen that water from the Cemetary well is considerably harder (183 ppm) than that from the sites to the east and west (105 and 127 ppm). The analysis of water from 14-8-53-17 shows harder water yet. This would suggest that the gravel terrace on which it is located is the source of the harder water in the Cemetary well.

Sulphate content appears to decrease in an easterly direction, down the gradient of the channel. It is most likely introduced into the channel in the groundwater discharged from adjacent bedrock. Sulphates originate from oxidation of finely disseminated pyrite in shale and/or solution of gypsum from bedrock. Inasmuch as the channel widens going east, the percentage of groundwater from direct percolation of precipitation increases, thus diluting that contributed from bedrock. This probably explains the observed

decrease in sulphate content.

The extremely small concentration of chlorides indicates uncontaminated water, as high chloride content commonly suggests sewage contamination. Therefore its absence in these waters shows that no such contamination is occurring.

Alkalinity is a term used to define the ability of water to neutralize acid. It is a composite of bicarbonates, carbonates, and hydroxides (and occasionally silicates) of sodium, calcium and magnesium. These are lumped together and identical samples can yield analyses varying by 5 percent. Values under 500 ppm are most common and quite acceptable in drinking water.

Nitrites and nitrates indicate the presence of organic contamination of water. Their complete absence from the foregoing analyses therefore is proof that no organic contamination has occurred.

Iron in quantities over 0.3 ppm does not do physical harm to humans, but will cause rust staining on clothes, plumbing fixtures and kettles. Iron is one of the most common elements found in igneous and sedimentary rocks, and is present to some extent in almost all surface water and groundwater. In the Edson aquifer, the concentration decreases eastward, no doubt for the same reason that sulphates decrease eastward. The source would be ferrous iron compounds in shales of the Paskapoo Formation. These no doubt account in part for the color of the green shales of the area. Again, as the groundwater from bedrock becomes increasingly diluted by downward percolating precipitation containing little or no iron, its concentration must decrease eastward.

To be effective in control of tooth decay, fluoride content should be at least 0.9 ppm, and not over 1.7 ppm. Therefore, the limited quantities present in these analysis are insufficient to aid in prevention of dental problems.

The source of soda in groundwater in Alberta is mainly sodium-rich clays, such as bentonite in the bedrock and surficial deposits. Concentrations shown in these analyses are well below upper acceptable limits.

Bacterial examinations of samples from the three pump test sites were also conducted. No harmful bacteria were reported from the Cemetary well nor the Gas Plant well. However, total Coliforms at the Lagoon site were 5.1, and S.P.C. was over 3000, which are not satisfactory.

Officials of the Edson Health Unit have pointed out that drilling operations often introduce minor contamination. Once a well is disinfected, such contamination is permanently removed. Using the coefficient of vertical permeability (P' = .077) calculated for this site, it would take 31 years for sewage effluent at the surface to percolate vertically to the aquifer. This, with the lack of nitrites and nitrates in the water indicates that no sewage contamination could have occurred, and that the bacteria present were most likely introduced by drilling.

Upon completion of the drilling program, all remaining pumping and observation wells were disinfected with bleach, then capped, in order to prevent contamination.

Conclusions and Recommendations

The Edson aquifer has adequate potential for almost all foreseeable water needs, both for the town and future industrial growth. Wells should be spaced at least 1000 feet apart, preferably 1500 feet, and drilled along the center of the channel. As more wells are drilled, the maximum allowable pumping rate of each will be lowered slightly because of mutual interference of their cones of depression. Safe yields are about 112 gpm however. Water is of excellent quality both for municipal and industrial use, and in no way exceeds acceptable upper limits for any common ions.

Acknowledgements

The author appreciates the help and interest shown in this program by town officials at Edson and their efforts to co-operate in all phases of it. Hi-Rate Drilling, Stettler, did an excellent job of drilling and aquifer testing. Much valuable help was given by technical staff of the Water Resources Division and by the Research Council of Alberta Groundwater Division.

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APPENDIX I - Logs of Drill Holes and Wells

Well No. 3 Drilled 1931. Lot 16, Block 5, Plan 12, Static level 0',
Pumping rate - 166 gpm.
Casing - 108' of 16"
16' of 6"
Perforated - 5' perforations every 15' from 20' to 108'

Depth	Material
0 - 20	Soil
20 - 90	Shale
90 - 98	Sand rock
98 - 108	Shale
108 - 124	Sand rock

Well No. 4 Drilled July 1949. Lot 16, Block 18, Plan 12, Static level 12'.
Pumping rate - 81 gpm.
Casing - 42' of 16"
120½' of 10"

Depth	Material
0 - 20	Yellow clay
20 - 46	Blue Clay
46 - 52	Shale with water
52 - 71	Sandy shale
71 - 76	Soft sandstone, water bearing
76 - 88	Sandy shale
88 - 99	Green shale, hard sandstone, water bearing
99 - 120	Green shale

Well No. 5 Drilled August, 1954. Lot 11, Block 64, Plan 17, Static level 1960 - 117.5'.
Casing - 54' of 16"
104' of 10 3/4"
Perforated - 52' - 57'
74' - 80'
97' - 104'

Depth	Material
0 - 11	Yellow clay
11 - 20	Silt and clay
20 - 38	Boulders and clay
38 - 52	Sandy clay
52 - 57	Soft sandstone, water bearing

Depth	Material
57 - 74	Blue shale
74 - 80	Hard sandstone, water bearing
80 - 97	Sandy shale
97 - 104	Hard sandstone, water bearing
104 - 170	Grey shale
170 - 175	Sandy shale
175 - 196	Sandstone, water bearing
196 - 217	Shale
217 -	Very hard ledge
218 - 230	Grey shale
230 - 235	Very soft shale
235 - 241	Shale
241 - 243	Hard sandstone, water bearing
243 - 254	Shale
254 - 257	Sandstone, water bearing
257 - 285	Shale
285 - 291	Very hard sandstone, water bearing
291 - 316	Shale
316 - 328	Sandy shale
328 - 347	Sandstone, water bearing
347 - 355	Shale

Well No. 6 Drilled 1956. Lot 13, Block 144, Plan 17,
Pumping rate - 40 gpm
Casing - 155' of 8 5/8"
Total depth - about - 320'
No log available

Well No. 7 Drilled 1957. Lot 12, Block 141, Plan 17, Static level 69.8'
Pumping rate - 70 gpm
Casing - 125' of 8 5/8"
Perforated - 85' - 124'

Depth	Material
0 - 35	Brown clay
35 - 55	Blue clay
55 - 76	Shale
76 - 85	Sandstone, water bearing
85 - 104	Shale
104 - 126	Sandstone, water bearing
126 - 171	Shale
171 - 175	Sandstone
175 - 225	Sticky shale
225 - 245	Sandstone, water bearing
245 - 310 ?	Sticky shale

Well No. 8 Drilled 1957. Lot 10, Block 116, Plan 17, Static level 71.6' (1958)

Pumping rate - 30 gpm
Casing - 85' of 10 3/4"
125' of 8 5/8"
Perforated - 104' - 122' (Uncased below 125')

Depth	Material
0 - 66	Sand with water
66 - 80	Sand with some clay
80 - 102	Sandy shale
102 - 109	Grey sandstone, some water
109 - 166	Sandy shale
166 - 189	Sandstone
189 - 250	Blue shale with coal
250 - 270	Blue sandy shale with coal
270 - 287	Blue shale
287 - 315	Grey sandstone with hard spots

Edson Test Holes and Well Logs, 1960

Test Hole No. 60-1 Lsd. 13-14-53-17-W5 - Elev. 2941.7'

Depth	Material
0 - 12	Brown clay
12 - 94	Blue clay and boulders
94 - 99	Gravel and sand
99 - 100	Sandy shale

Hole plugged and abandoned

Test Hole No. 60-2 Lot 12, Block 12

Depth	Material
0 - 12	Brown clay
12 - 35	Sandy blue clay
35 - 90	Very sandy clay
90 - 125	Clay and boulders
125 - 127	Coal and sand
127 - 134	Gravel and sand
134 - 136	Sandstone
136 - 140	Sandy shale

Casing pulled and abandoned

Test Hole No. 60-3 Lsd 13-11-53-17-W5 Elev. 2975

Depth	Material
0 - 25	Blue clay
25 - 70	Sandy clay
70 - 100	Clay and rocks
100 - 120	Sandy shale

Hole plugged and abandoned

Test Hole No. 60-4 Lsd. 12-14-53-17-W5, Elev. 2971.1

Depth	Material
0 - 25	Brown clay
25 - 65	Sandy clay
65 - 123	Clay and boulders
123 - 126	Sand and gravel
126 - 130	Sandy shale

Test Hole No. 60-5 Lsd. 13-14-53-17-W5, Elev. 2954.8; T = 7200

Depth	Material
0 - 45	Clay
45 - 50	Sand
50 - 108	Clay and rocks
108 - 116	Sand and gravel, water bearing
116 - 117	Sandy shale

Left as observation well

Test Hole No. 60-6 Southeast Lot 10, Block 146, Elev. 2970.5; T = 4000+

Depth	Material
0 - 15	Brown clay
15 - 45	Sandy clay
45 - 119	Brown clay and boulders
119 - 131½	Sand and gravel, water bearing
131½ - 134	Sandy grey shale

Test Hole No. 60-7 South of Lot 5, Block 147

Depth	Material
0 - 15	Brown clay
15 - 45	Sandy clay
45 - 119	Clay and boulders
119 - 131.5	Sand and gravel, water bearing

Left as observation well

Test Hole No. 60-8 Lot 8, Block 147

Depth	Material
0 - 12	Brown clay
12 - 40	Sandy clay
40 - 115	Clay and rocks
115 - 118	Gravel, water bearing
118 - 120	Sand, water bearing

Test Hole No. 60-9 - Location Lsd 8-12-53-17-W5

Depth	Material
0 - 5	Gravel
5 - 15	Sand, boulders, clay
15 - 42	Shale with layers of sandstone
42 - 45	Sandstone

Abandoned

EDSON Well Log, 1961

Well No. 61-1, Lot 13, Block 131

Casing 118' of 8"
Screened 118' - 131', #80 slot
Pump test rate 220 gpm. T = 10,000, S= 2.1×10^{-4}
Safe yield greater than 120 gpm.

Depth	Material
0 - 21	Light brown plastic clay
21 - 31	Light brown plastic clay, interbedded with light blue-grey silty clay
31 - 57	Light grey silty clay
57 - 60	Light grey silty clay, interbedded with light grey plastic clay
60 - 77	Light brown till, silty to sandy
77 - 87	Light grey till, silty clay
87 - 99	Grey till, silty, small shale pebbles
99 - 107	Grey clay till, coarse sand and pebbles
107 - 116	Grey till, soft plastic to silty
116 - 118	Till, more pebbly
118 - 131	Gravel, coarse to fine quartzite
131 - 133	Sandstone

Edson Test Drilling, 1962

Test Hole No. 62-1

Location - Block Y, Edson
Elevation 2968 feet

Depth	Material
0 - 5	Sandy brown clay
5 - 15	Brown clay
15 - 30	Grey clay
30 - 52	Fine grey sand
52 - 100	Sandy grey clay
100 - 110	Sandy brown clay
110 - 125½	Sandy grey clay
125½ - 133½	Sand and gravel, alternating fine and coarse layers, becoming generally finer with depth
133½ - 134	Blue shale

Test Hole No. 62-2

Location Approx. 25 feet north-west, town well no. 5
(Lot 16, Block 144) Elevation 2990 feet

Depth	Material
0 - 23	Brown clay
23 - 45	Sandy grey clay
45 - 65	Sandy brown clay
65 - 70	Sandy grey clay
70 - 80	Sandy brown clay
80 - 92	Sandy grey clay
92 - 92½	Boulder
92½ - 122	Sandy grey clay
122 - 128	Grey clay
128 - 134	Sandy grey clay
134 - 135	Boulders
135 - 139	Slightly sandy grey clay
139 - 152½	Gravel
152½	Shale

Test Hole No. 62-3

Location Lot 10, Block 151, Edson
Elevation 2990 feet

Depth	Material
0 - 25	Brown clay
25 - 117	Sandy grey clay
117 -	Sandstone (?) boulder
117 - 130	Sandy grey clay

Depth	Material
130 - 138	Gravel
138 - 140	Sand
140 - 142	Gravel
142 - 144	Blue-grey shale

Test Hole No. 62-4

Location .5 miles south of north-east corner, Sec. 22, Tp. 53 R. 17, W5. - Elev. 2993 feet

Depth	Material
0 - 25	Brown clay
25 - 40	Grey clay
40 - 64	Sandy grey clay
64 - 80	Blue shale

Test Hole No. 62-5

Location East side block 113, Edson
Elevation - 2979 feet

Depth	Material
0 - 10	Surface fill
10 - 20	Grey and brown clay
20 - 30	Grey clay
30 - 46	Grey and brown clay
46 - 50	Grey shale, thin coal seam at about 50 feet

Test Hole No. 62-6

Location - NE corner Sec.9, Tp. 53, R. 17, W.5

Depth	Material
0 - 16	Brown clay
16 - 30	Sandy grey clay
30 - 40	Grey clay
40 - 95	Sandy grey clay
95 -	Sandstone (?) boulder
95 - 107	Sandy grey clay
107 - 116	Gravel
116 - 120	Blue shale

Test Hole No. 62 - 7

Location - S of railway tracks, between CNR reservoir and road
Elevation 2975 feet

Depth	Material
0 - 13	Brown clay
13 - 35	Grey clay
35 - 72	Sandy grey clay
72 - 74	Sandy grey clay, some pebbles
74 - 75	Sandstone boulder
75 - 85	Sandy grey clay, some pebbles
85 - 103	Sandy grey clay, sandstone and shale particles
103 -	Sandstone boulder
103 - 110	Sandy grey clay
110 - 117	Dirty gravel, becoming cleaner with depth
117 - 121	Sandy grey shale

Test Hole No. 62-8

Location - On abandoned railway grade, .15 miles N. of SW corner Sec.9, Tp. 53, R. 17, W.5th.

Depth	Material
0 - 10	Fill
10 - 15	Muskeg
15 - 35	Grey clay
35 - 69	Sandy grey clay
69 - 75	Greenish-grey sand
75 - 86	Sandy blue-grey shale

Test Hole No. 62-9

Location - On abandoned railway grade, .4 miles N. of SW. corner Sec. 9, Tp. 53, R. 17. W5th

Depth	Material
0 - 5	Fill
5 - 15	Muskeg
15 - 18	Blue clay
18 - 35	Grey clay
35 - 38	Grey clay, some pebbles
38 - 69	Sandy grey clay
69 - 70	Boulder (?)
70 - 73	Blue shale
73 - 87	Gravel
87 - 93	Sandy blue shale

Test Hole No. 62 -10

Location - Lot 5, Block 150, Edson
Elevation - 2970 feet

Depth	Material
0 - 22	Brown clay
22 - 30	Grey clay
30 - 50	Sandy grey clay, some pebbles
50 - 65	Sandy grey clay
65 - 76	Coarse yellow sand
76 - 77	Sandy grey clay
77 - 78	Sandstone boulder
78 - 81	Sandy grey clay
81	Sandstone boulder
81 - 132	Sandy grey clay
132 - 134	Gravel and sand
134 - 138	Sand
138 - 143	Sand and gravel
143 - 147	Grey shale

Test Hole No. 62-11

Location Lot 3, Block 150, Edson
Elevation 2975 feet

Depth	Material
0 - 21	Brown clay
21 - 35	Soft grey clay
35 - 62	Silty grey clay
62 - 84	Brown sand, sandstone boulders
84 - 131	Grey clay and rocks
131 - 136	Gravel
136 - 138	Sand
138 - 142	Sand and gravel

Test Hole No. 62 - 12

Location W. side of road, .25 miles N. of SE. corner Sec. 12, Tp. 53, R. 18, W. 5.

Depth	Material
0 - 41	Dark grey sand
41 - 93	Grey clay and rocks
93 - 96	Soft silty sandstone
96 - 123	Clay and rocks
123 - 133	Gravel
133 - 140	Shale

Test Hole No. 62 - 13

Location Block 12, Edson
Elevation 2986 feet

Depth	Material
0 - 8	Brown clay
8 - 93	Grey clay
93 - 143	Weathered shale
143 - 150	Sandy grey shale

Test Hole No. 62 - 14

Location - S. of block 149, Edson
Elevation 2964 feet

Depth	Material
0 - 32	Clay
32 - 78	Sand
78 - 123	Grey clay
123 - 131	Sand and gravel

Test Hole No. 62 - 15

Location Lot 11, Block 149, Edson
Elevation 2968 feet

Depth	Material
0 - 17	Yellowish - brown clay
17 - 71	Grey clay
71 - 82	Sandy brown clay
82 - 122	Grey clay and boulders
122 - 135	Gravel

Test hole 222E - June 27, 1968 - Lsd. 3-5-54-16-W5 - Elev. 2893 feet

Depth	Material
0 - 5	Silty clay
5 - 30	Sand
30 - 62	Silt
62 - 70	Gravel
70 - 84	Sandy clay
84 - 87	Sandstone boulder
87 - 95	Unconsolidated bedrock
95 - 101	Clay
101 - 111	Saskatchewan gravel
111 - 125	Sandstone

Test hole 221E - June 27, 1968 - Lsd. 12-5-54-16-W5 - Elev. 2835feet

Depth	Material
0 - 15	Clay loam
15 - 21	Gravel
21 - 30	Hard sandstone
30 - 35	Sandstone
35 - 50	Siltstone and shale

Test hole 255-E -Nov. 13, 1968 - Lsd 9-23-53-17-W5 - Elev. 2835 feet

Depth	Material
0 - 3	Loam
3 - 20	Silty clay
20 - 25	Clay
25 - 30	Shale and siltstone
30 - 35	Sandstone
35 - 45	Shale and siltstone
45 - 57	Sandstone
57 - 121	Clay
121 - 132	Gravel
132 - 140	Bedrock

Test holes 68-5P and 68-6P. May 30, 1968. Lsd 8-23-53-17-W5 Elev. 2949

Depth	Material
0 - 2	Silty loam
2 - 12	Clay
12 - 18	Silty clay loam
18 - 32	Silty clay
32 - 116	Silty clay loam with pebbles
116 - 124	Saskatchewan gravel
124 - 130	Sandstone
130 - 138	Shale and siltstone
138 - 140	Sandstone

One of these completed as an Observation well - Casing - 124' of 2 7/8", slotted. T = 9100. Other one (35 feet east) completed as pumping well, 117' of 6" casing, #20 slot Johnson screen installed 117' - 124'. T = 8250. Pumping rate 50 gpm.

Test hole 68-3P June 11, 1968. Lsd. 1-23-57-17-W5- Elev. 2953.2 feet

Depth	Material
0 - 2	Clay
2 - 63	Silty clay
63 - 94	Silty clay loam
94 - 95	Sandstone boulder
95 - 116	Silty clay loam
116 - 121	Sand and gravel
121 - 125	Siltstone and sandstone

Completed as Observation well. Casing - 122' of 2 7/8" slotted. T = 12,550

Test hole 68-4P June 10, 1968 - Lsd. 8-23-53-17-W5 - Elev. 2951.4

Depth	Material
0 - 2	Silt
2 - 12	Clay
12 - 28	Silty clay loam
28 - 32	Silty clay
32 - 95	Silty clay loam
95 - 101	Gravel
101 - 116	Silty clay loam
116 - 124	Gravel
124 - 126	Shale and siltstone

Completed as Observation well. Cased 125' of 2 7/8", slotted T = 16,500

Test hole 68-1P June 1, 1968. Lsd. 12-13-53-17-W5 - Elev. 2946.4 feet

Depth	Material
0 - 9	Clay
9 - 21	Silty clay
21 - 31	Very fine sandy loam
31 - 35	Silty clay loam
35 - 42	Silty clay
42 - 82	Silty clay loam and pebbles
82 - 96	Gravel
96 - 104	Silty shale

Test hole 256-E. Nov. 13, 1968. Lsd 16-23-53-17-W5 - Elev. 2986.9 feet

Depth	Material
0 - 3	Loam
3 - 12	Silty clay
12 - 80	Clay
80 - 90	Claystone
90 - 107	Sandstone, lost circulation

Test hole 68-7P June 26, 1968. Lsd. 1-16-53-17-W5 - Elev. 2972.0 feet

Depth	Material
0 - 34	Silty clay
34 - 111	Clay loam
111 - 116	Clay
116 - 128	Silty shale

Test hole 68-8P July 23, 1968. Lsd. 7-16-53-17-W5 - Elev. 2977.3

Depth	Material
0 - 4	Light brown sandy clay
4 - 8	Soft light brown clay
8 - 34	Greyish soft clay
34 - 71	Grey till with sand, stones, shales and brown sandstone
71 - 72	Boulder
72 - 81	Grey till with shale
81 - 95	Brown sand and some shale
95 - 112	Grey till and shale
112 - 118	Saskatchewan Gravel
118 - 140	Siltstone

Completed as observation well. Casing 120' of 2 7/8", slotted and developed. T = 19,800

Test hole 223E June 27, 1968. Lsd 9-16-53-17-W5- Elev. 2980.4 feet

Depth	Material
0 - 20	Silt
20 - 35	Very fine sand
35 - 50	Clay
50 - 55	Siltstone
55 - 60	Shale
60 - 90	Siltstone
90 - 106	Sandstone
106 - 110	Shale and sandstone

Test hole 224E June 28, 1968. Lsd 8-16-53-17-W5 - Elev. 2981.5 feet

Depth	Material
0 - 35	Silt
35 - 80	Clay
80 - 87	Gravel
87 - 92	Silt
92 - 104	Clay
104 - 105	Gravel
105 - 114	Clay
114 - 129	Saskatchewan gravel
129 - 140	Sandstone

Test Hole 259E Nov. 18, 1968 SE-16-53-17-W5 - Elev. 2973 feet

Depth	Material
0 - 2	Muskeg
2 - 40	Silt
40 - 107	Clay
107 - 117	Saskatchewan Gravel
117 - 120	Sandstone

Test hole 68-13P May 28, 1968 Lsd. 13-9-53-17-W5 - Elev. 2985.8 feet

Depth	Material
0 - 6	Silty clay (artificial fill)
6 - 14	Peat moss
14 - 22	Clay
22 - 24	Silty clay
24 - 48	Clay
48 - 52	Silty clay loam
52 - 60	Sandy silty loam
60 - 95	Very fine sandy silt
95 - 102	Silt
102 - 105	Sandy loam
105 - 115	Saskatchewan gravel
115 - 120	Siltstone

Test hole 68-13P

Depth	Material
120 - 130	Sandstone, grey, fine to medium

Completed as pumping well. Casing 109.6' of 6", with 25 slot 10 foot Johnson stainless steel screen. Pumped at 30 gpm. T = 12,200

Test hole 68-11P May 28, 1968. Lsd. 5-9-53-17-W5 - Elev. 2980.2 feet

Depth	Material
0 - 4	Silty clay (artificial fill)
4 - 11	Peat moss
11 - 34	Clay
34 - 40	Silty clay
40 - 76	Silty clay loam and pebbles
76 - 87	Saskatchewan gravels
87 - 99	Sandstone, light grey, fine

Test hole 68-9P May 30, 1968. Lsd. 4-9-53-17-W5 - Elev. 2979.0 feet

Depth	Material
0 - 8	Clay (artificial fill)
8 - 14	Peat moss
14 - 32	Clay
32 - 52	Silty clay loam
52 - 68	Sandstone, olive-yellow, medium
68 - 70	Sandstone, grey, soft

Test hole 68-16P June 28, 1968. Lsd. 4-16-53-17-W5 - Elev. 2998.1 feet

Depth	Material
0 - 10	Silty clay
10 - 12	Sandy clay
12 - 46	Silty clay loam
46 - 54	Silty clay
54 - 126	Clay loam, with shale and sandstone pebbles
126 - 129	Saskatchewan gravel
129 - 131	Gravel and sand
131 - 150	Siltstone and sandstone

Test hole 68-15P July 8, 1968, Lsd. 1-17-53-17-W5 - Elev. 2996.4 feet

Depth	Material
0 - 14	Silty clay
14 - 16	Sandy loam
16 - 64	Silty loam
64 - 121	Clay loam

Test hole 68-15P

Depth	Material
121 - 131	Saskatchewan Gravel
131 - 133	Siltstone

Completed as an observation well. Casing - 131 feet of 2 7/8", slotted 121feet - 131 feet and developed. T = 46,500 (?)

Test hole 217-E June 25, 1968. Lsd. 1-17-53-17-W5 - Elev. 2992.6

Depth	Material
0 - 10	Silt
10 - 35	Silty clay loam
35 - 45	Coaly sand
45 - 50	Sand
50 - 70	Sandy clay
70 - 75	Gravel
75 - 80	Clay loam
80 - 115	Clay
115 - 127	Saskatchewan gravel
127 - 140	Sandstone

Test hole 68-12P. July 10, 1968. Lsd. 13-9-53-17-W5 - Elev. 2985.9

Depth	Material
0 - 108	Same as 68-13P
108 - 118	Saskatchewan sand and gravel

Completed as observation well. Casing 108' of 2 7/8", and 12' of 2" perforated, developed. T = 5200.

Test hole 218E June 26, 1968. Lsd 5-17-53-17-W5 - Elev. 3030.2 feet

Depth	Material
0 - 25	Silt
25 - 75	Clay
75 - 80	Sandstone boulder
80 - 115	Clay
115 - 140	Shale and siltstone
140 - 154	Clay
154 - 165	Saskatchewan gravel
165 - 170	Sandstone

Test hole 219E June 26, 1968. Lsd. 7-17-53-17-W5 - Elev. 3038 feet

Depth	Material
0 - 5	Clay loam
5 - 10	Sandstone
10 - 35	Shale and siltstone
35 - 50	Sandstone
50 - 57	Shale and siltstone
57 - 60	Sandstone
60 - 65	Shale and siltstone

Test hole 220E June 26, 1968. Lsd 9-17-53-17-W5 - Elev. 3010 feet

Depth	Material
0 - 9	Clay loam
9 - 25	Sandstone
25 - 40	Shale and siltstone
40 - 72	Sandstone
72 - 80	Shale and siltstone

Test hole 68-24P. July 24, 1968. Lsd 13-8-53-17-W5 Elev. 3012.0 feet

Depth	Material
0 - 4	Clay loam
4 - 36	Silty clay
36 - 54	Silty clay, trace of clay
54 - 62	Silty clay to clay loam
62 - 74	Clay loam, pebbles
74 - 78	Saskatchewan gravel
78 - 100	Siltstone

Completed as water well. Casing 79 feet of 6", slotted 75 - 79 and developed. Static level 26 feet. Pumping rate of 4 gpm.

Test hole 68 - 17P May 25, 1968. Lsd. 4-7-53-17-W5 - Elev. 3037 feet

Depth	Material
0 - 8	Clay
8 - 9	Gravel
9 - 71	Sandy clay
71 - 76	Siltstone
76 - 79	Hard sandstone
79 - 88	Sandstone, grey, fine

Test hole 68-17P

Depth	Material
88 - 98	Sandstone, light yellow-brown, medium, soft
98 - 100	Shale
100 - 110	Sandstone, grey, fine

Test hole 68 - 18P May 24, 1968. Lsd. 5-7-53-17-W5 - Elev. 3024 feet

Depth	Material
0 - 2	Clay loam
2 - 14	Sand, trace of coal
14 - 16	Silty clay
16 - 52	Fine sand
52 - 54	Shale, colored
54 - 61	Sandstone, grey
61 - 64	Shale, grey
64 - 80	Siltstone

Test hole 68-19P May 27, 1968. Lsd. 8-12-53-18-W5 - Elev. 3032 feet

Depth	Material
0 - 3	Silty clay
3 - 6	Sand
6 - 9	Clay
9 - 20	Medium sand
20 - 26	Fine sand
26 - 36	Fine sand with silty clay, some coal
36 - 80	Fine sand and coal
80 - 85	Very fine sand with coal
85 - 90	Silstone
90 - 100	Sandstone

Test hole 68-21P. May 23, 1968. Lsd. 15-35-52-18-W5 - Elev. 3023.7 feet

Depth	Material
0 - 11	Brown sand, coaly 7'-9'
11 - 72	Clay, some pebbles
72 - 78	Shale, grey
78 - 82	Sandstone, grey, very hard
82 - 93	Siltstone
93 - 95	Sandstone
95 - 100	Siltstone

Test hole 68-22P May 24, 1968. Lsd. 7-2-53-18-W5 - Elev. 2958.2 feet

Depth	Material
0 - 14	Coarse sand
14 - 17	Gravel and sand

Test hole 68-22P

Depth	Material
17 - 42	Silty clay loam
42 - 49	Sandstone, grey, hard
49 - 60	Shale, greenish grey

Test hole 68-23P May 23, 1968 Lsd. 11-2-53-18-W5 Elev. 2946.0 feet

Depth	Material
0 - 10	Silty clay
10 - 14	Fine silty loam
14 - 20	Saskatchewan gravel
20 - 28	Shale, grey
28 - 30	Sandstone, dark grey

Test hole 216E June 25, 1968. Lsd. 16-2-53-18-W5 - Elev. 3037.9 feet

Depth	Material
0 - 20	Silty clay
20 - 44	Clay
44 - 50	Silty clay
50 - 65	Clay loam
65 - 70	Sandstone boulder
70 - 80	Clay loam
80 - 95	Shale
95 - 119	Clay loam
119 - 133	Saskatchewan gravel
133 - 140	Sandstone

Completed as a pumping well. Casing - 121 feet of 6", with 10 feet of #25 slot Johnson stainless steel screen at 121 - 131 feet. Developed. Static level 102.85 feet. Pumping rate 25 gpm. T = 18,800.

Test hole 257 E Nov. 14, 1968. SE - 11-53-18-W5. Elev. 3044.5

Depth	Material
0 - 4	Silty loam
4 - 20	Silt
20 - 60	Clay
60 - 64	Sandy clay
64 - 66	Sandstone, hard
66 - 120	Clay
120 - 128	Saskatchewan gravel
128 - 140	Siltstone

Completed as an observation well. Casing - 126 feet of 2 7/8" slotted and developed.

Test hole 258E - Nov. 15, 1968. SE-11-53-18-W5. - Elev. 3067.7 feet

Depth	Material
0 - 3	Loam
3 - 30	Silt
30 - 45	Clay, Lost circulation 40 feet
45 - 65	Medium sand
65 - 120	Sandstone
120 - 125	Claystone

Test hole 261E - Nov. 21, 1968. NW 2-53-18-W5 - Elev. 3034.6 feet

Depth	Material
0 - 2	Loam
2 - 34	Silt
34 - 40	Clay
40 - 50	Very fine sand
50 - 65	Claystone
65 - 75	Sandstone
75 - 84	Clay
84 - 90	Gravel and clay
90 - 123	Saskatchewan gravel
123 - 125	Claystone

Completed as observation well. Casing - 125 feet of 2 7/8" slotted and developed.

SW-11-53-18-W5 Test Wells for Hudson's Bay Oil and Gas

Test Well 1 July 1964

0 - 12	Clay
12 - 23	Clay and boulders
23 - 26	Sand
26 - 33	Clay
33 - 35	Sand
35 - 44	Clay
44 - 65	Sand
65 - 70	Clay
70 - 71	Sand
71 - 76	Sandstone (blind)
76 - 85	Sandstone
85 - 97	Sandstone (blind)
97 - 154	Sandstone with some hard ledges
154 - 165	Shale

Tested at 32 gpm.

Test Well 2 July 1964, Located 25 feet south of Test Well 1.

Depth	Material
0 - 64	Clay with sand layer
64 - 84	Clay
84 - 85	Sandstone
85 - 130	Sandstone with some hard layers
130 - 152	Sandstone
152 - 165	Shale

Test Well 3 July, 1964, Located 420 feet north of Test Well 1.

Depth	Material
0 - 68	Clay with sand layers
68 - 73	Sand
73 - 82	Shale
82 - 90	Sandstone
90 - 98	Shale
98 - 140	Sandstone
140 - 152	Sandstone with hard layers
152 - 168	Shale

This well was electric-logged.

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